APRIL 1958

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ILLUMINATING ENGINEERING

Journal of the
ILLUMINATING ENGINEERING SOCIETY

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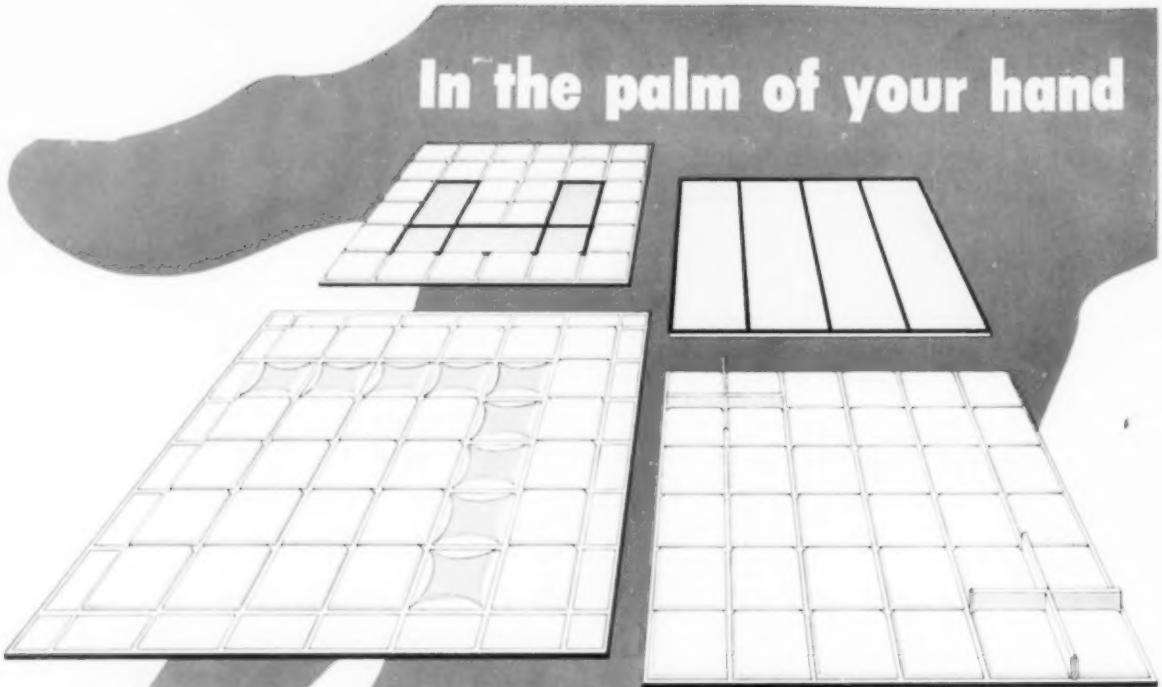

an infinite variety of ceiling designs which can be laid out, bill-of-materialed and priced right in the field

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WAKEFIELD CEILING '58

Catalog describes and illustrates Wakefield Ceiling '58 in detail and lists district offices in U. S. and Canada.

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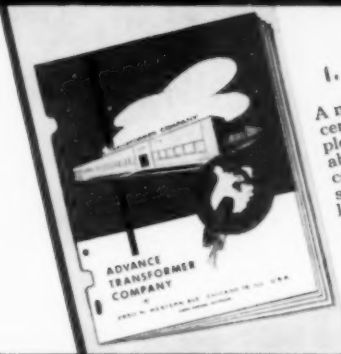
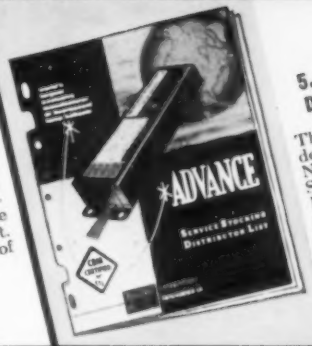


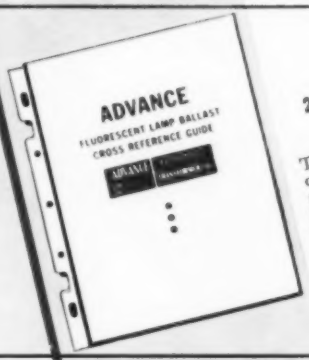
1. BALLAST MANUAL

A new manual on Fluorescent Lamp Ballasts, completely illustrated, tells all about ballast circuits and construction. Fully describes all phases of ballast manufacture, installation and operation. Shows how to test ballasts and measure current, illustrates a new easy-to-use ballast quiet rating chart. Be sure to get a copy of this helpful manual.



5. SERVICE-STOCKING DISTRIBUTORS' LIST

This bulletin completely describes the ADVANCE Nation-wide Service-Stocking Distributor Plan. It lists alphabetically by state and city more than 700 authorized distributors who carry a complete stock of ADVANCE Ballasts to give immediate replacement service for any ballast.



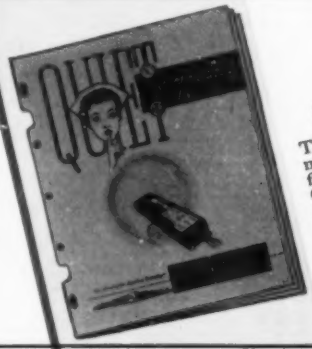
2. CROSS-REFERENCE GUIDE

This guide lists all types of ADVANCE Ballasts, as well as those of other manufacturers. It shows alphabetically the replacement ballast numbers of all popular ballasts in an easy-to-use reference guide.

6. WIRING DIAGRAM AND LEAD LENGTH BULLETIN

A new bulletin for users of Fluorescent Lamp Ballasts gives all the latest available specifications on size and lead lengths of ADVANCE ballasts. Also included are wiring diagrams for preheat, slimline and instant start, rapid start and quick start and circline ballasts.

only the world's largest exclusive lamp ballast manufacturer offers all this!



3. BUYER'S GUIDE

The world's largest and most complete listing of fluorescent lamp ballasts. Classifies and gives all electrical data including wattage, voltage and dimensions of all ADVANCE Fluorescent Lamp Ballasts.

7. VISA VOLT®

Visa-Volt labelling is an exclusive Advance color coding for instant positive Fluorescent Lamp Ballast voltage identification.

8. ADVAN guard

Advan-guard, another Advance exclusive, is an Internal Thermally actuated protective device that adds years to Ballast life.

INDIVIDUAL PACKAGING

Individual packaging of Fluorescent Lamp Ballasts was introduced by Advance. These convenient cartons have an end label for instant identification, eliminate stocking problems and assure factory-fresh merchandise.

4. MERCURY VAPOR LAMP BALLASTS

This bulletin describes and covers various types of ballasts for mercury vapor lamp operation. Illustrations, diagrams, specifications and engineering data and electrical characteristics are all included.

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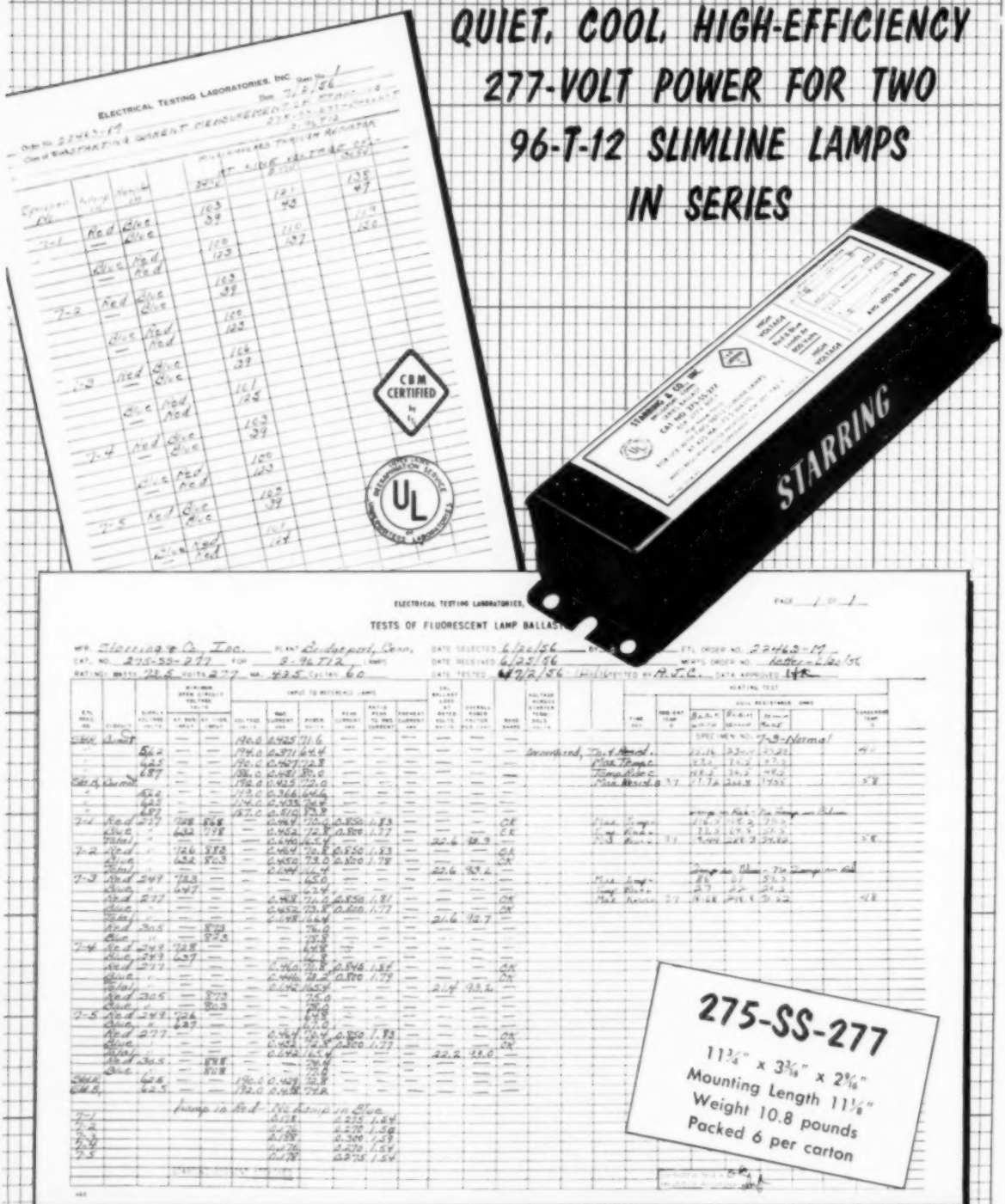

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THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

April
1958

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Contents

169 Lighting for Selling

174 Discomfort Glare at Low Adaptation Levels — Part III, Multiple Sources — Russell C. Putnam and Keith D. Bower

185 Practical Daylighting Prediction — J. W. Griffith, W. J. Arner and O. F. Wenzler

191 Daylight PLUS Electric Light — In Schools — H. S. Gregory

193 Analysis of Light Distributions from Linear Source Street Luminaires — Robert G. McPhail

203 I.E.S. Lighting Data Sheet — Series XXIII
Lighting a Church (15-27)

205 Photometer for Measurement of Effective Intensity of Condenser-Discharge Lights — Charles A. Douglas

209 I.E.S. Home Lighting Data Sheet
Transilluminated Curtains (22-62)

211 Lamps for Aircraft Lighting

213 I.E.S. Guide for Measuring and Reporting Daylight Illumination

217 Views and Opinions — Hazards and Pitfalls in Footcandle Calculations — Edward Balogh

8A Lighting News

31A I.E.S. Committee Personnel

42A National and Local Officers of I.E.S.

48A I.E.S. National Technical Conference

65A Index to Advertisers

Sustaining Members — Refer to January 1958 ILLUMINATING ENGINEERING.

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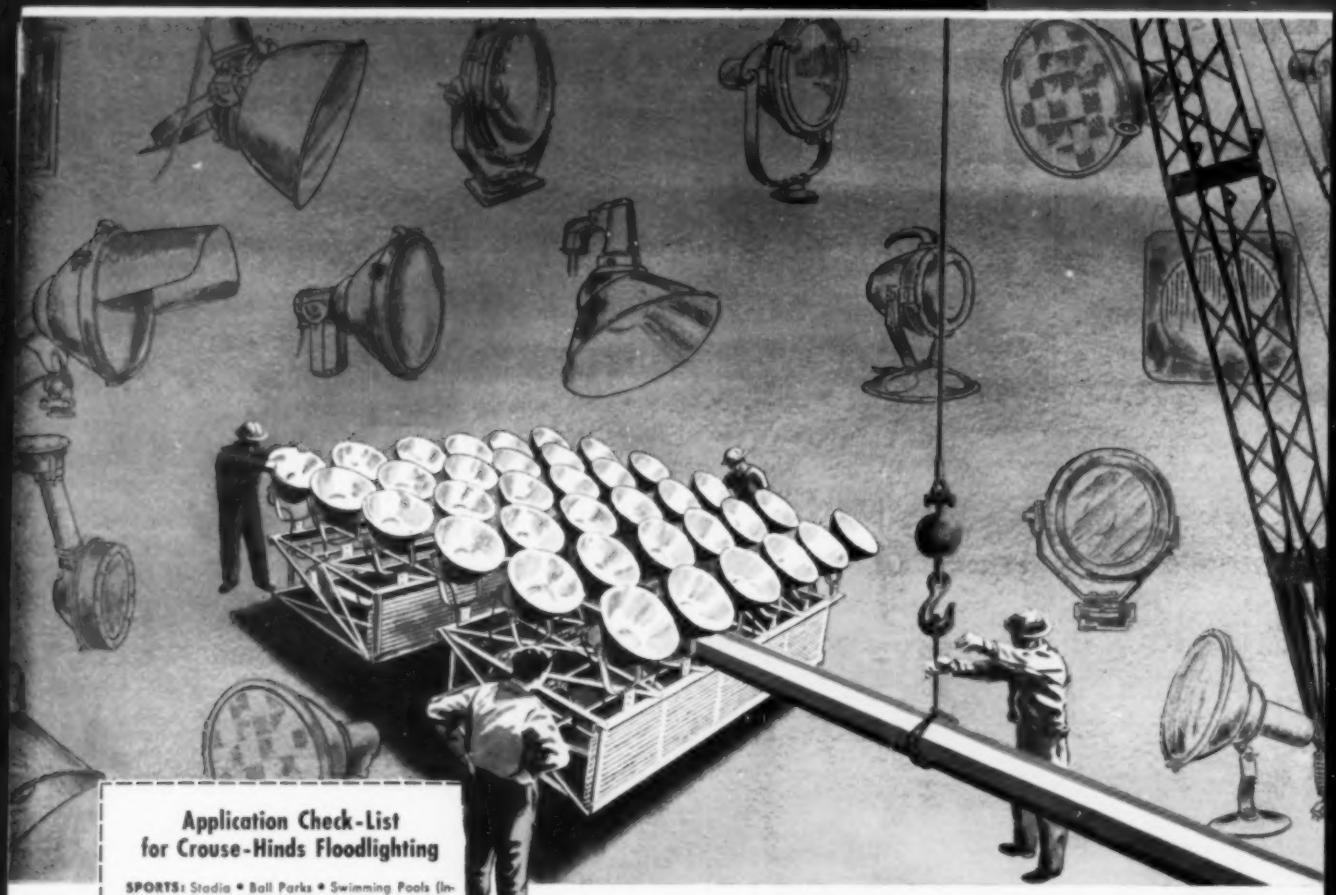

Application Check-List for Crouse-Hinds Floodlighting

SPORTS: Stadia • Ball Parks • Swimming Pools (Indoor & Outdoor) • Gymnasiums • All Summer & Winter Sports (Indoor & Outdoor)

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CONSTRUCTION: Roads & Streets • Dams, Seaways & Piers • Detours • Buildings • Reconstruction of Disaster Areas

INDUSTRIAL AND UTILITY: Parking Areas • Freight Yards • Weigh Stations • Docks & Piers • Staging Areas • Production Work Areas

TRAFFIC: Tunnels • Viaducts • Bridges • Underpasses • Walks • Public Squares, Thruway Interchanges & Rest Areas • Cloverleafs • Parking Areas

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Name your floodlighting need – for construction, emergency, utility, traffic, display, decoration, sports, underwater, or hazardous-area use. Crouse-Hinds can supply floodlights *designed specifically for each application.*

A quick scanning of the widely varied applications included in the Check-List at left proves again that floodlights often provide *better light from few source points at less cost* than conventional lighting.

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Send us a brief description of your lighting problem, or an indication of the floodlight types in which you are interested. We will send literature containing product information applying to your problem by return mail.

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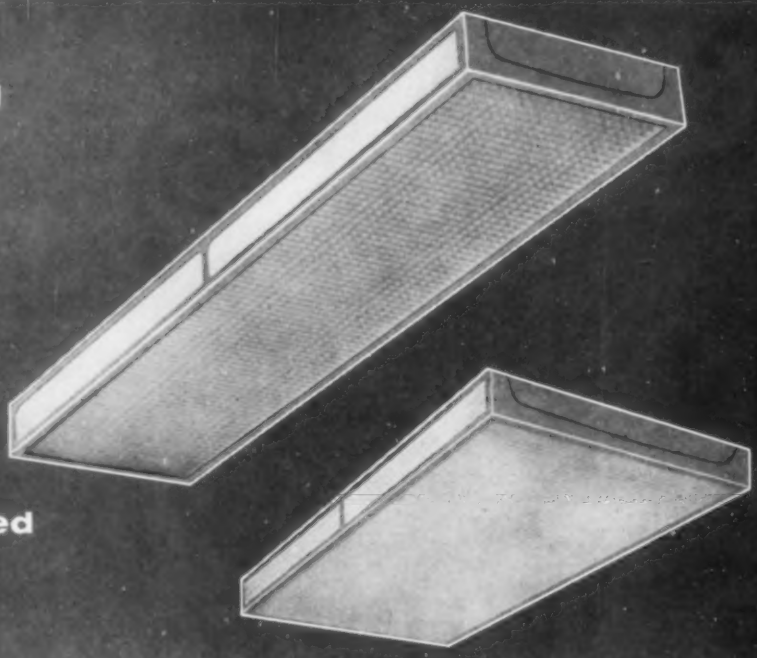

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1. Compact Chassis
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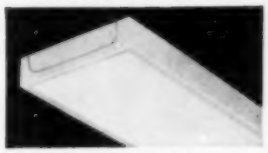
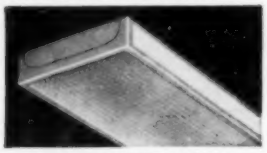
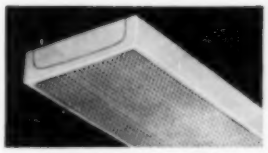


ALBA-LITE GLASS

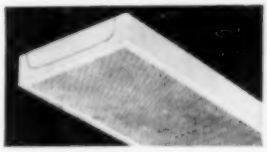


ONE-PIECE PLASTIC LOUVER

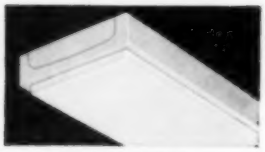


EXTRULITE CLEAR PLASTIC

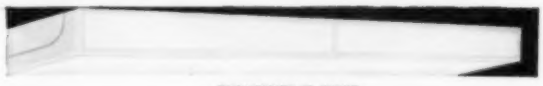
FLAT PLEXIGLAS PANEL



LOW BRIGHTNESS LENS



DISHED PLASTIC



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lighting for...

SELLING

As all smart and successful salesmen know, many influences are reflected in a customer's decision to make or not to make a purchase. Of these influences, lighting is most completely at the command of the merchandiser, and its wise and effective handling is one of his most powerful tools.

Jewelry Store

Small town or large, competition from shopping centers is one major problem shared by all "downtown" stores. Levinson's Jewelry Store in Mount Pleasant, Pa., re-modeled to meet this competition, as part of a town-wide merchant's campaign to emphasize the fact that they can offer all the advantages of a shopping center plus the local trust and good will of home-owned stores.

Points for consideration in the re-modeling included a bad ceiling condition caused by periodic water accidents in the apartment above, and the pre-Christmas season during which no jewelry store would close.

Luminous ceiling lighting with an integrated hanger fixture was selected for several reasons:

(1) the ceiling would completely conceal the unattractive fiberboard ceiling,

(2) the mounting channels reinforce the strength of the true ceiling,

(3) by placing the lamps on 18-inch centers on the hanger fixture it was possible to keep the cavity to a 12-inch depth and the room ceiling a height of 9 feet,

(4) 75 footcandles maintained general illumination is provided.

Strips of vinyl plastic, three feet wide, are rolled in on double "U" channel tracks suspended from the lighting fixture channels. Over the front edge of the display cases, an additional 100 footcandles are provided by 150-watt PAR spots inserted in the ceiling tracks.

The display cases and wall cases are further highlighted by fluorescent strip which supplies 40 footcandles.

Finishes and reflectances are: wall above and between cases, light blue, 50% RF; wall cases and display cases, natural birch wood, 40% RF; rear wall, medium red, 40% RF.

This installation, by John W. Arblaster, West Penn Power Co., Connellsville, Pa., was entered in the Pittsburgh Section's contest for MMILJ.

Automobile Showroom

One good thing leads to another, and good sales efforts at Giguere Automobile Ltee. led to such increased business that this Quebec auto showroom was forced to expand. This, in turn, led to the incorporation of good lighting as a further selling technique, pointing to further increases in business.

This was not accomplished without some convincing, but all concerned finally agreed on the plan suggested by the lighting engineer. Dimensions of the "L"-shaped showroom are 139 feet long by 21 feet wide, one leg being 84 feet and the other 55. Ceiling height is 13½ feet. Outer walls are of glass in aluminum frames; ceiling is white, and floor is of light pink terrazzo with black designs. Upper part of the inside walls is bright yellow, the lower part red brick and glass windows; doors and window frames are natural oak finish.

The suggested plan for general lighting in this modern building called for 15 recessed troffers with Alzak aluminum shields, each containing two 73-watt T12 slimline lamps. These are spaced on eight-foot centers down the legs of the "L," centered between the inner and outer walls. At the corner angle, a 4-foot-square recessed unit, with acrylic plastic shielding, uses eight 40-watt lamps.

Along the inner wall, 16 recessed downlights, with 150-watt reflector flood lamps and controlling lenses, are mounted on eight-foot centers half-way between troffer centers. Two similar units are in an "office" area at the corner, where prospective Buick owners sign on the line.

Accents and highlights are supplied by a total of 39 recessed 150-watt adjustable spots which are mounted, on four-foot centers, along the entire length of the outer wall. A simple form of decoration is produced by indirect lighting from 18 wall plaques.

Illumination levels vary from 40 to 80 footcandles.

Installation, which won first prize in the Quebec Chapter's My Most Interesting Lighting Job contest, is by George A. Watters, Quebec Power Co., Quebec. Architect for the building was Maurice Mainguy.

Rug Display

Meelan's Oriental Rug and Interior Decorators Display Room in Williamsport, Pa., is only leased by the merchandiser. This business angle presented a lighting problem in that, while the decorator wanted a custom job for displaying his rugs, the building owner requested a design flexible enough to adapt to many types of businesses, should there be a future change of tenant.

The decorator also wanted a lighting design which would reflect well on his professional reputation, and a system which would provide good color rendition for his fabrics.

The building is long and narrow — 19 feet wide by 90 feet long, with wall lines and symmetry broken by offsets, structural beams, a prominent and ugly stairway which had to remain, and the usual plumbing. The inadequate lighting system was from a skylight and nine enclosing globes suspended from the 12-foot high metal ceiling.

The first decision made was to treat the ceiling as two areas, breaking the apparent length of the room. A luminous ceiling 19 feet wide by 39 feet long was used in the front section of the store, with channel support rails running laterally. This arrangement also increases the apparent width of the area.

A still further benefit from this arrangement is in the maintenance. The single-lamp fluorescent units are mounted in the same direction as the support rails, so that for re-lamping only a small portion of the vinyl plastic ceiling must be rolled back. The 12-foot-high metal ceiling was painted flat white and 27 eight-foot and 4 four-foot single-lamp fluorescent units are surface mounted on it. Height of the plastic ceiling had to be at least 10 feet to accommodate full length rug and drapery displays. Slide grip hangers were mounted directly to the fluorescent units and were wire-suspended to leveling hangers on the support channels and lowered to the 10-foot ceiling height.

Accent lighting in this area is by channel spots incorporated into the painted perforated hardboard strips, which not only give added support to the ceiling, but also add a sparkling effect with light from the plenum glinting through the perforations. These spots can be shifted along the channel support rails to any position in the ceiling with little loss of plastic, so as the type of business might change, the ceiling can vary with it.

Although decorators sometimes insist on a color of light matching daylight, they can be convinced that fabrics will be viewed in the home under artificial illumination, and the warm white fluorescent combined with incandescent provides good color rendition. Illumination level under the luminous ceiling is 50 footcandles maintained.

A higher level of 85 footcandles is provided in the rear of the store to draw attention to the back wall displays and to attract customers to the rear area. A dropped acoustical ceiling was designed to

give the 10-foot ceiling height and to de-emphasize the stairway.

A total of 24 three-lamp recessed troffers with low-brightness lens are mounted on six-foot centers with matching floods installed at the ends of the troffer rows. Adjustable spots are added between troffers for special feature displays. Highlights, visible in the photograph, on the large rug display housings have subsequently been eliminated by proper aiming of accent lighting.

This installation won second prize for J. W. MacMillen, Pennsylvania Power & Light Co., Williamsport, Pa., in the Eastern Pennsylvania Section's contest for MMILJ.

Hardware Sales

The first "selling" job at the Motroni-Heard Lumber Co., Woodland, Calif., was that of illuminating engineering. The lighting engineer had to convince the owners that they did *not* want a rustic low-reflectance finish on a ceiling which sloped from 12-foot minimum to 15-foot maximum in the 31-foot width of the hardware sales area.

Once the owners agreed to have the ceiling and 2 x 10-inch beams painted a flat white, calculations were made, using the I.E.S. Zonal Method, for lighting levels with various types of lighting systems.

On the basis of these calculations, the owners selected an indirect system using one row of five 2-lamp fixtures on 33-inch hangers, and one row of the same on 48-inch hangers. These units operate on 800 ma ballasts.

Results were levels of 80 footcandles directly below the fixtures and 55 footcandles between rows.

A similar installation in an adjoining paint shop provides 70 to 120 footcandles.

Installation by Charles A. Dean, Pacific Gas and Electric Co., Sacramento, Calif. won third prize in the Mother Lode Chapter's My Most Interesting Lighting Job Contest.

Women's Specialty Shop

One problem common to many stores, that of "bowling alley" appearance, was encountered at the Outlet Millinery in Bridgeport, Conn. Dimensions are 22 feet wide by 145 feet long. To mitigate this condition, the design approach in lighting incorporated the illumination of areas as an integral part of the overall design: to illuminate, decorate and delineate the various sales departments.

Four distinct areas evolved, following this approach, making four departments, individual in appearance as well as merchandise. A fifth area, that of perimeter lighting of wall displays integrates the whole in a continuous line.

Area 1 — Show windows. Adjustable recessed spots provide approximately 75 footcandles. Ceiling is robin's egg blue; walls are of white brick and warm gray plywood panels; floor is carpeted in warm gray.

Area 2 — Entrance and first quarter of the store. Handbags and other accessories are displayed in this department, which has a 9-foot 6-inch high plaster ceiling. Recessed floods supply approximately 50 footcandles, and showcases are lighted by overhead recessed spots. Ceiling in this area is also robin's egg blue, walls are warm gray, floor is an off-white terrazzo.

Area 3 — Center of store. Ceiling height is 12 feet in this department. General lighting is by 2-foot square recessed units with plastic shields, using standard white fluorescent lamps. Recessed spots give sharpness to floor displays and showcases. Illumination level is 60 footcandles.

Side walls are a light gray, and curtain walls above are 4-foot wide panels in alternating shades of flame, deep green, pink, white and robin's egg blue. Ceiling is white acoustical tile and the floor is the same as that in the front sales area.

Area 4 — Rear of store. Here, a luminous ceiling is mounted 10 feet from the floor, with cool white fluorescent lighting to encourage eye, and customer movement to the rear. The forward half of the department has pendant-mounted, perforated brass hooded floodlamps hung from opaque panels in the ceiling. An elaborate chandelier, also pendant-mounted from an opaque panel, is centered in the back half of the section. This area has approximately 65 footcandles.

Colors in the luminous ceiling area help to set it off as a separate department. Side walls are off-white, with curtain walls above in a cocoa brown wallpaper, with overprint of metallic gold. Fixtures are cocoa brown and off-white and the floor is covered with blue-green carpeting. A sub-section, also under the luminous ceiling, houses a foundation department on one side, and a hat bar on the other. Foundation department walls are in vertical stripes of dusty pink and white, with white showcases and dusty pink panels. The millinery bar has white counters set against a curved wall covered in an off-white fabric with metallic gold thread.

Accents of polished brass and natural walnut are used throughout the store.

Perimeter lighting, using deluxe cool white fluorescent strips mounted in open-top coves 30 inches out from the wall, runs from the entrance area through to the luminous ceiling area in the rear. Curtain walls above the shelving and hanging have plastic grid ceilings lighted by deluxe cool white strip to backlight the merchandise. Vertical warm white fluorescent strips behind wall mirrors in the rear quarter of the store wash the walls with light. Lighting level averages 50 footcandles. The perimeter lighting technique integrates the various departments without detracting from their individual appearance, and moves the customer's glance, at merchandise level, to the rear of the store.

This installation was the entry of Bernard S. Vinick, of Bernard Vinick Associates, Hartford, Conn., in the Connecticut Section's contest for My Most Interesting Lighting Job.

Discomfort Glare at Low Adaptation Levels Part III—Multiple Sources

By RUSSELL C. PUTNAM and KEITH D. BOWER

THE QUESTION of discomfort glare is of great interest to the illuminating engineer. Lighting design for interior lighting applications has long been concerned with visual comfort and the avoidance of discomfort glare. In the last few years, also, it has been growing in importance in the consideration of engineers engaged in street and highway lighting.

Various techniques have been used by past researchers to study the glare problem. The BCD criterion as developed by Luckiesh and Guth[1] (the borderline between visual comfort and discomfort) has been used in previous research work done at Case Institute of Technology and is the visual sensation rating used in this study. Putnam and Faucett[2] considered light sources of different visual sizes applicable to street lighting conditions when viewed on the horizontal line of sight against low brightness backgrounds. A further study of the same problem was carried on by Putnam and Gillmore[3] for sources above the horizontal line of sight and with a background brightness of 0.01 footlambert. This present investigation continues the researches with studies of how the borderline brightnesses between comfort and discomfort change with angle above the horizontal for varying background brightnesses (adaptation levels), source sizes, and for different combinations of multiple sources. The glare sources used are the same visual sizes as typical street lighting luminaires and the adaptation brightnesses are typical of the surround brightnesses encountered in street lighting applications at night.

The present investigation consisted of four parts. First the observers made BCD measurements of a circular source alone on the line of vision in order to tie in the results of this group of observers with those of previous investigations.[2,3] Then a study was made of the BCD brightness of a single source above the line of vision for background brightnesses of from 0.001 to 1.0 footlambert. The third part consisted of studies of simulated incandescent and fluorescent sources at ten, twenty, and thirty degrees above the horizontal line of sight, the simulated fluorescent readings being taken for a range of background brightness also of from 0.001 to 1.0 footlambert. Finally, the simulated incandescent and fluorescent sources were combined to get the effect of multiple sources. All observations were taken with a background brightness of 0.1 footlambert except where otherwise noted.

More than three thousand evaluations were taken by fourteen observers during this investigation. The age of the observers ranged from nineteen to sixty-five years. Each observer repeated a similar situation at least twice and frequent checks were made on each person. All observers were asked to evaluate sensations without any knowledge of what the results were or how they compared with others.

Experimental Apparatus

A large hemisphere approximately two meters in diameter was used as in previous investigations to give a background of easily controlled brightness over the entire visual field. The glare sources were placed in this hemisphere at the correct angles and sizes for a given position of the observer. The evenly controlled brightness on the interior of the hemisphere was caused by a centrally located source which was shielded from the observer. The headrest located the position of the observer so that his horizontal line of sight was fixed on the circular glare source at the middle of the hemisphere (Fig. 1). A flashing cycle of twenty seconds was employed similar to that used in previous discomfort glare studies. When the comparison tests were run, the comparison source was always on the line of vision and exposed alternately with the sources above the direct line of vision. The first three consecutive flashes were one second in duration and were separated by one second off periods. After the third flash a five-second off period followed. The next consecutive flash interval began by interchanging the order of the two sources. Otherwise the remaining half of the twenty-second cycle remained the same as the first. This flashing sequence was chosen because the momentary expo-

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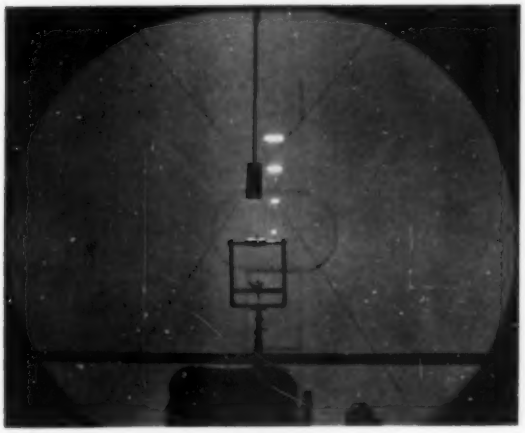


Figure 1. View of hemisphere simulating a field of uniform background, showing glare sources and headrest position.

sure keeps the observer's eye adaptation at a level more nearly equal to that of the background brightness and also because it is easier for an observer to evaluate a sensation of brightness from a short exposure than it is to judge the same sensation when prolonged. The light sources were held at a low standby brightness which matched that of the background during the off periods.

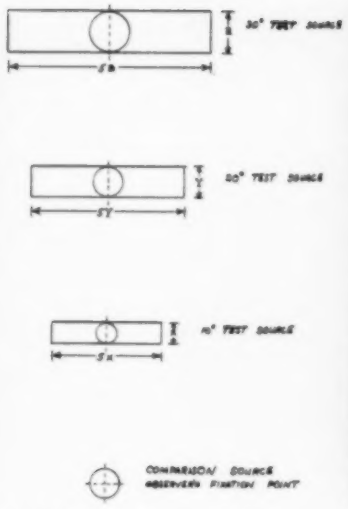
Experimental Procedure

At first each observer was placed in a uniform background environment of 0.1 footlambert. After adapting to this level he was asked to set a source subtending a solid angle of 0.0001 steradians at a brightness which he considered to be at the borderline between comfort and discomfort. This served to acquaint the observer with the evaluations which follow throughout the rest of the experiment, and establish an average (geometric) BCD value for this group of observers. The order in taking each set of readings was varied continuously so as to eliminate suggestive influences. The method of repeating the readings for each observer on subsequent days and averaging the results correspond to that used in the previous BCD researches.

The observers were now asked to compare a sensation from a source above the line of vision to the sensation produced by the comparison source on the line of vision. They were instructed to match sensations produced by the light source seven and one-half degrees above the line of vision to the sensation from the source they were looking at directly. Both sources were the same size (circular solid angle = 0.0001 steradian) and the comparison brightness was set for the BCD of these observers as obtained previously. As the readings continued the comparison data were taken with the test source moved to angles of fifteen degrees, twenty degrees, and thirty degrees in the field of vision above the horizontal line of sight. This gave the average BCD brightnesses for off the line of vision sources evaluated by these fourteen people for a background brightness of 0.1 footlambert. Later six observers were chosen, whose averages were very close to the average of all fourteen, for readings under adaptation levels of 0.001, 0.01, and 1.0 footlambert.

During the next series of tests the observers were asked to match the visual sensations of sources of different size. The size and brightness of the horizontal comparison glare source was kept the same as in previous tests. At first the glare source was placed at ten degrees above the horizontal axis and its size was computed from the actual size of a typical incandescent or mercury street lighting unit (one hundred square inches) mounted at a typical height (thirty feet). The visual size of this glare source in steradians was determined to be 0.000032 steradian. This value corresponded to a unit approximately one hundred and forty-four feet ahead and twenty-five feet above the driver's eyes. The observer varied the intensity of the test glare source above the line of vision until he matched BCD sensations in the same manner as described previously. Other glare sources simulated the same units at a twenty-degree elevation approximately seventy feet distant (0.00013 steradian), and a thirty-degree elevation at forty-four feet (0.00027 steradian) (Figs. 2 and 3). In like manner, simulated fluorescent sources were made for the same angles and distances. Their horizontal dimensions at each position were five times the diameters of the circular sources and their vertical dimensions were the same as these diameters (Figs. 3 and 4). The BCD brightnesses of these sources were determined by matching sensations with the comparison source.

The geometric averages of these BCD readings were then computed. The brightnesses of the simulated glare sources were then set to these values. The sensation of various combinations of two or three sources exposed simultaneously was matched to that of the comparison source. Here the observer varied the brightness of the comparison source because the glare sources above the horizontal were set at different brightnesses. The flashing sequence was identical with that of the other comparison tests except that either two or three test sources were flashed simultaneously and alternately with the comparison source. When the observer thought that he had a match of sensations he would report to the experimenter and thus establish the bright-



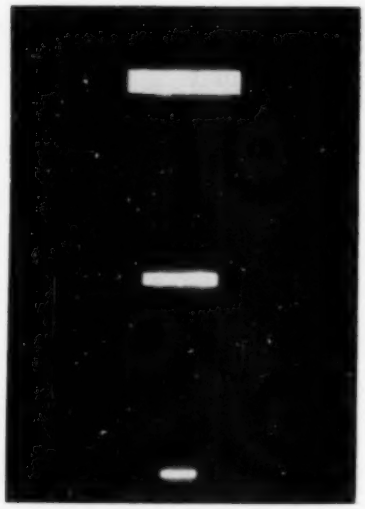


Figure 2. (Left) Multiple simulated incandescent glare sources as seen in the hemisphere.
Figure 3. (Center) Diagram showing relationship between sizes of simulated fluorescent and incandescent sources.
Figure 4. (Right) Multiple simulated fluorescent glare sources as seen in the hemisphere.

ness sensation caused by the addition of multiple sources above his point of visual fixation. The experimenter recorded this brightness reading and since it was the brightness of the comparison source of which the BCD was already known, the ratio of any combined source sensation to the BCD was just the ratio of the reported brightness of this comparison source to its average BCD value of one hundred and sixty footlamberts.

At the conclusion of the above series of tests, the observers were brought back into the laboratory to do a check run on the first series of evaluations that originally determined their average BCD. It was found that their estimations of the particular sensation rating changed only very slightly (about five per cent for the group average) over a prolonged period of about five months.

Results of Investigation

The results of the BCD evaluations for this group of observers shows that they are more sensitive to initial glare than the other two groups which have participated in similar Case researches. The present group has a much wider range in individual evaluations, varying from 8 to 1420 footlamberts, with a geometric BCD average of 160 footlamberts. The variation among individuals is not unusual because of the many psychological and physiological factors which influence the subjective appraisal of such bright areas.[4] However, ohe low value of 8 footlamberts and the high value of 1420 footlamberts do give cause for speculation. These results are extraordinary, but the observers giving them have been checked independently several times in different ways, and their evaluations have never been found to change significantly. In the other parts of the investigation all observers, including these extremes, followed similar trends. The interest of this investigation is centered on the trends of observers' evaluations, rather than on the individual's evaluation of BCD. It is also concerned with the observers' consistency within themselves. In this regard, their individual estimations are found to vary considerably; however, the group trends are the same throughout each test. An indication of this is given by comparing the observers' first set of BCD evaluations to a similar set made after a five-month interval. With a background of 0.1 footlambert and a 0.0001 steradian circular source placed on the line of vision, the two geometric averages are respectively 160 footlamberts and 168 footlamberts. An increase in BCD appraisal of only five per cent is noted. Also, the individual trends indicated throughout the experimental work never change significantly. Each observer's trend is similar to the group's, and, therefore, the slopes of the curves can be considered characteristic of the trends of a large population.

The four curves in Fig. 5 show that the BCD brightness of a source must be increased as its angle above the direct line of vision is raised. The curves for background brightness of 1.0 footlambert and 0.1 footlambert show trends similar to those developed by Luckiesh and Guth[1] for a background level of ten footlamberts, and also to that of Petherbridge and Hopkinson.[5] The two curves which indi-

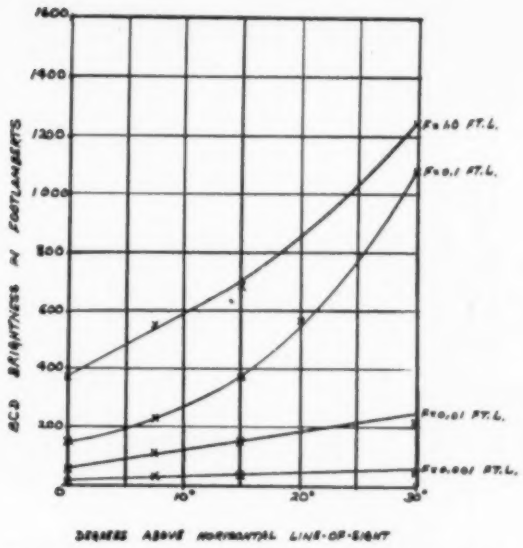


Figure 5. The relationship between the BCD brightnesses of a source, subtending a solid angle of 0.0001 steradian, and the angle above the horizontal line of sight for four different background brightnesses (*F*).

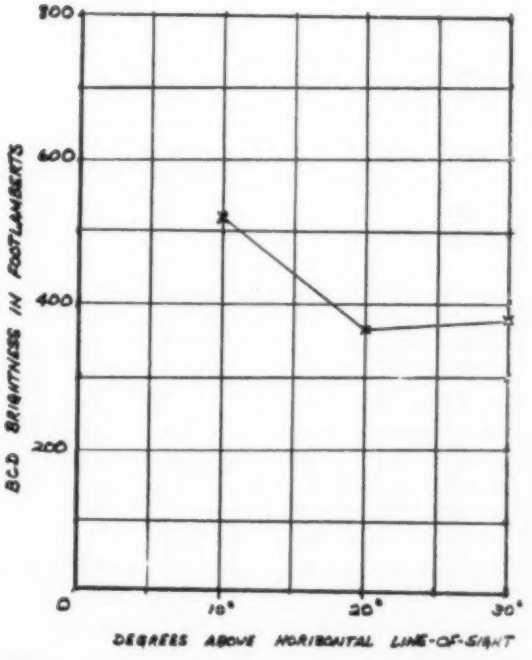


Figure 6. The relationship between the BCD brightnesses of simulated incandescent street lighting sources and the angle above the horizontal line of sight for a background brightness of 0.1 footlambert. The visual sizes of sources at 10°, 20°, and 30° are respectively 0.000032 steradian, 0.00013 steradian, and 0.00027 steradian.

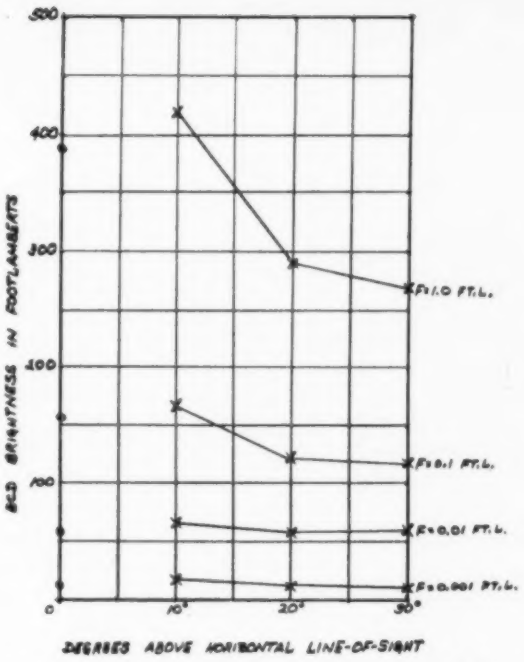


Figure 7. The relationship between the BCD brightnesses of simulated fluorescent street lighting sources and the angle above the horizontal line of sight for four different background brightnesses (*F*). The comparison of the visual sizes of three glare sources with those of Fig. 6 is shown in Fig. 3.

cate BCD brightness variation under respective adaptation levels of 0.01 footlambert and 0.001 footlambert, show linear variations as the angle is varied, these changes corresponding closely to the curves published by Putnam and Gillmore.[3] The four curves indicate a transformation from linear to exponential variation as the background is raised from 0.01 footlambert to 0.1 footlambert. An explanation for this abrupt change might be found in the literature of the structure and psychology of the eye.* It is speculated that the respective response and sensitivity characteristics of the rods and cones in the retina change radically at about this level.

In a practical street lighting condition, the visual size of luminaire increases along with the vertical angle as the distance from the driver decreases. Figs. 6 and 7 give the results of such a study. For each condition of source type and background brightness, it is interesting to note that in every case the BCD brightnesses at twenty and thirty degrees are approximately the same. At ten de-

*In the Illuminating Engineering Society's literature, it is generally agreed that a transition between rod and cone vision occurs in the range of 0.1 footlambert and 0.001 footlambert.

TABLE I.

	Fluorescent Average	Incandescent Average	Per Cent
10°	167 ft-L	525 ft-L	32%
20°	122 ft-L	360 ft-L	34%
30°	119 ft-L	370 ft-L	32%

grees, however, there is a decided increase in BCD brightness over the BCD brightness at twenty degrees, the increase getting smaller with the lower background brightness conditions. This agrees with the results of calculations made by another researcher computed from the basic BCD data applied to backgrounds with higher adaptation levels than used in the present research.[6]

There is a very close correlation between the BCD brightnesses of the simulated incandescent-mercury sources and the fluorescent sources taken at the same background brightness (0.1 footlambert); the fluorescent source giving readings from 32 to 34 per cent of the simulated incandescent-mercury in every case (Table I).

In considering a realistic street lighting situation, the combined sensation from multiple sources must be taken into account. Table II gives the sensation brightnesses of the comparison source on the line of vision when matched to the sensation from various combinations of glare sources above the direct line of vision. This is illustrated by the curves in Figs. 8 through 12 which indicate that the combined source sensation brightness increases nearly linearly with the number of sources added. A pronounced departure from direct additivity, however, is especially noted when the two sources are both located near the periphery of the observer's visual field (at 20 and 30 degrees). This result was noticed by each observer, and the readings were spread out over a long period of time so

TABLE II.

Vertical Angle	Incandescent Average	Fluorescent Average
Background $F = 0.001$ ft-L		
10° - 20°	——	30.5 ft-L
10° - 30°	——	30.0 ft-L
20° - 30°	——	35.0 ft-L
10° - 20° - 30°	——	45.5 ft-L
Background $F = 0.01$ ft-L		
10° - 20°	——	124 ft-L
10° - 30°	——	125 ft-L
20° - 30°	——	160 ft-L
10° - 20° - 30°	——	182 ft-L
Background $F = 0.1$ ft-L		
10° - 20°	312 ft-L	325 ft-L
10° - 30°	327 ft-L	326 ft-L
20° - 30°	397 ft-L	391 ft-L
10° - 20° - 30°	483 ft-L	481 ft-L
Background $F = 1.0$ ft-L		
10° - 20°	——	755 ft-L
10° - 30°	——	761 ft-L
20° - 30°	——	867 ft-L
10° - 20° - 30°	——	1144 ft-L

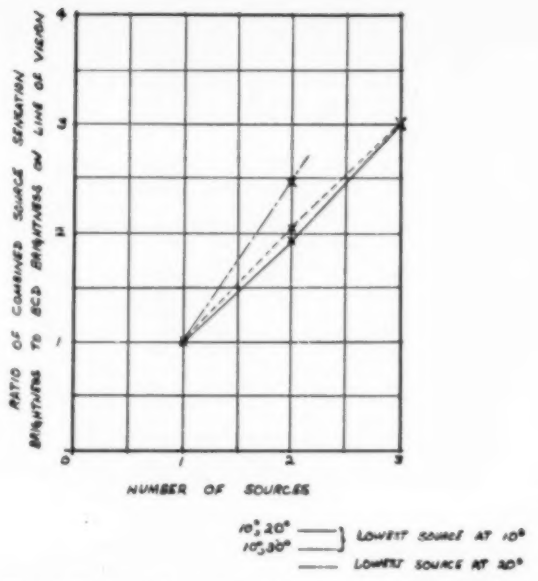


Figure 8. Incandescent multiple sources. The relationship between the combined simulated incandescent source sensation brightnesses and the number of sources located in various combinations at 10°, 20°, and 30° for a background brightness of 0.1 footlambert.

that the departure cannot be attributed to extreme fluctuations or subjective influence. The same trend is also in sharp evidence from the three curves produced for the fluorescent sources under general adaptation levels of 0.001, 0.01, and 1.0 footlambert. The direct additivity of the combined sensation of sources when one source is at ten degrees is in agreement with previous researches by Holladay which were taken under different conditions of source size and background brightness.[7] The non-additive phenomena that was observed when the sources were at twenty and thirty degrees is difficult to account for under the present limited knowledge of human visual responses. The illuminating engineer must wait for the physiologist and psychologist for an explanation of this phenomena; from the results of this investigation he can only point out that it exists.

The era of emphasis upon quality in lighting is opening up a new field of endeavor toward comfort on the lighted highways at night. Up to the present time, most researches have been concerned primarily with the amount of light necessary to provide adequate visibility. However, since World War II, the comfort in lighting has been studied from various viewpoints. Meaker and Oetting have published the visual comfort index (VCI) tables, which enable the field engineer to evaluate the lighting comfort of a proposed indoor installation.

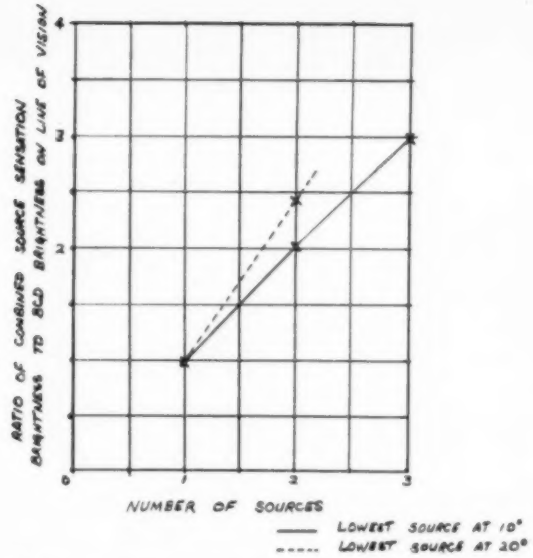


Figure 9. Fluorescent multiple sources. The relationship between the sensation brightnesses of simulated fluorescent street lighting sources and the number of sources located in various combinations at 10°, 20°, and 30° for a background brightness of 1.0 footlambert.

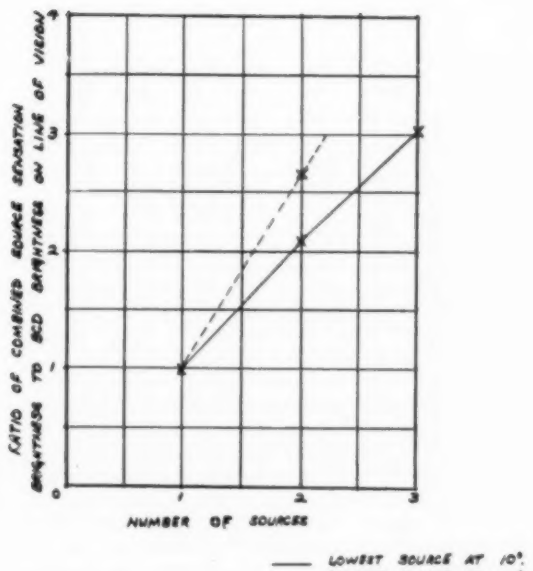


Figure 10. Fluorescent multiple sources. Combined effect of these simulated street lighting sources, as in Fig. 9, with a background brightness of 0.1 footlambert.

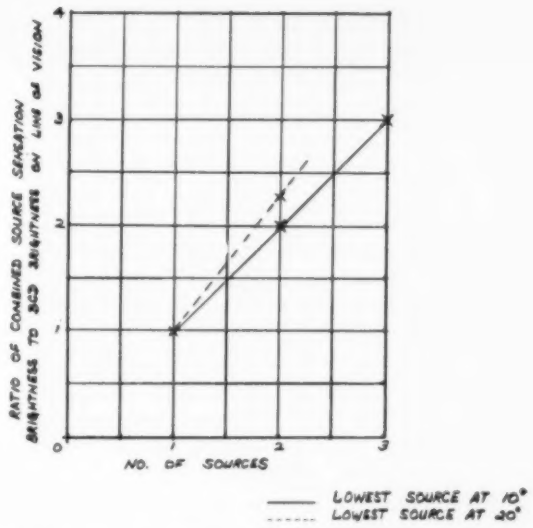


Figure 11. Fluorescent multiple sources. Combined effect of these simulated street lighting sources, as in Fig. 9, with a background brightness of 0.01 footlambert.

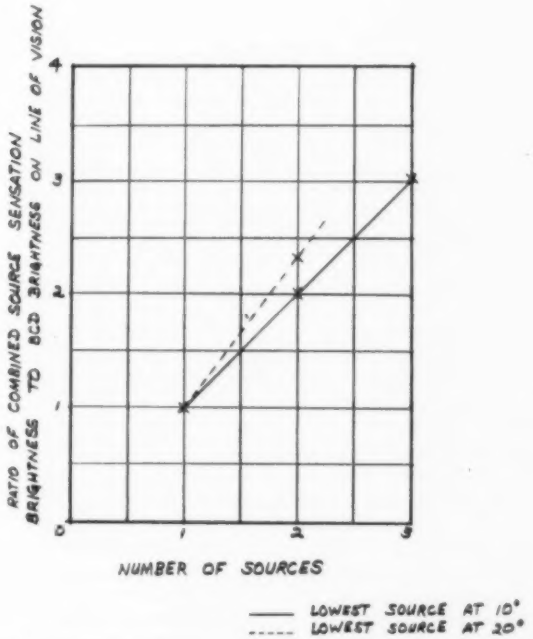


Figure 12. Fluorescent multiple sources. Combined effect of these simulated street lighting sources, as in Fig. 9, with a background brightness of 0.001 footlambert.

These tables combine the results obtained from BCD researches of Guth, the brightness ratio technique, and the glare factor formula.[8] They are now considered by illuminating engineers, as well as fixture manufacturers, as very helpful in establishing comfortable indoor lighting requirements.

The concept of comfort in lighting is as basic in outdoor as well as indoor applications. The VCI tables, as now developed, can only be used under working illumination levels between 10 and 125 footcandles,[8] and for certain luminaires for indoor lighting. For lower level backgrounds, including those of outdoor environment, no work on an establishment of a similar set of tables has ever been attempted. It is hoped, therefore, that results of this investigation will contribute to the accumulated knowledge on which future work may be based leading toward the establishment of tables which will be applicable to street and highway lighting, as well as adding to the general understanding of the very complex problem of visual comfort at low brightness levels.

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DISCUSSION

R. E. FAUCETT:* The authors are certainly to be complimented for their contribution of these valuable data. Their paper will surely serve as one of the major stepping stones toward the development of a method whereby the relative effectiveness of different street lighting systems can be accurately predicted before actual installation. Several investigators have contributed bits of information in this as well as other countries in an effort directed toward this mutual objective. It is my opinion that we are now very close to evolving a system of measuring and evaluating relative "seeability" of different techniques now used and proposed for street lighting purposes.

The authors have derived certain data indicating that the BCD value of a simulated fluorescent installation is approximately ⅓ that of a simulated incandescent or mercury installation. It is emphasized, however, that the results were

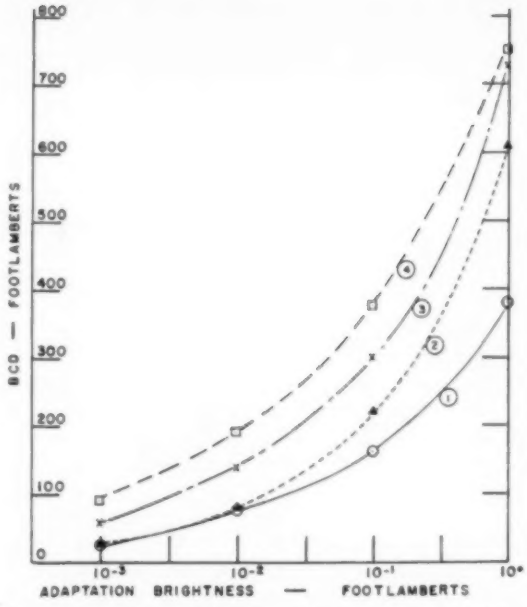

Figure A. Values of BCD for various adaptation brightnesses. Source size Q equals 0.0001 Steradian, from four investigators:

(1) Present study

(2) Calculated from equation proposed in authors' reference 1

(3) Data taken from authors' reference 2

(4) Calculated from equation proposed by Fowler, E. W., and Crouch, C. L., "Glare and Lighting Design," ILLUMINATING ENGINEERING, Vol. XXXVI, pp. 897-916, November 1941. (An application of Holladay's Formula.)

obtained as a strict academic measure of BCD with little coordinated regard to actual field conditions involving color, average pavement brightness, silhouette conditions, object brightness, vertical illumination, brightness uniformity ratios, and windshield cut-offs. Therefore, the reader is cautioned not to jump to conclusions concerning the "seeability" provided by a particular system as BCD is only *one* of the variables. It is quite possible that if two different systems were simulated (keeping constant all factors listed above) and the actual brightnesses, numbers and locations of the luminaires permitted to fall where they may, the relative BCD would be altogether different.

The authors state that their group of observers had a wide range of BCD response (8 to 1420, with a geometric average of 160 footlamberts). It is assumed that this response was obtained with a source size of $Q = 0.0001$ steradian on the line of sight as viewed against an adaptation brightness of $F = 0.1$ footlambert. The corresponding range obtained from another group of observers (Putnam and Bowers reference No. 2) was 42 to 2123 with a geometric mean of 268 footlamberts. This much detail of other investigations has not been made available to this discussor, so that it is not possible to make this direct comparison with other data. However, the tremendous range found between different individuals is not unexpected or extraordinary because of the many physiological and psychological

*General Electric Co., Outdoor Lighting Dept., Hendersonville, N. C.

factors which influence subjective appraisals. Therefore, in an effort to compare the absolute values obtained in some of the more recent studies, this discussor has plotted one set of data checkpoints common to all studies. This is shown on the accompanying graph.

The obviously remarkable thing here is the apparent parallelism of the resultant curves. It is therefore suggested that perhaps the mean of each set of data obtained from a group of individuals could be considered as one observer. We would then effectively have four sets of data that could be averaged, thereby producing a proposed "standard observer" representative of the average person. One of the major objections commonly raised to individual studies of this type is the lack of a statistically significant number of readings. The marriage of several sets of data could go a long way toward nullification of these objections.

One example in which the "standard observer" idea has been beneficial and widely accepted is the standard spectral response curve of the average human eye. Why not also evolve a family of standard BCD curves for the average human eye? This could provide the luminaire designer with practical maximum brightness design criteria.

CHARLES H. REX:* We should all feel appreciation for the diligence which Professor Putnam and Keith Bower have devoted to the task of obtaining data for evaluation of discomfort glare under roadway lighting conditions. Congratulations to the Illuminating Engineering Research Institute for supporting, sponsoring, and aiding this research project.

This work, together with prior studies, has been done with the impelling motive of *numerically* rating the relative comfort with which millions of drivers may *use* their streets and highways *at night*. These roadways — and the autos, trucks, and buses which travel over them — represent a tremendous multi-billion dollar transportation investment by the people. Increased night use will enhance the value of this investment. Roadway lighting will encourage night use. Properly applied, such lighting should make night driving safer and more pleasant.

These data are highly significant. When we can rate the relative comfort of roadway lighting, we can produce visibility with the comfort environment which people really desire.

One of the recent references to the comfort requirements in roadway lighting is contained in a statement by Joseph P. Barnett, Assistant Deputy Commissioner for the U. S. Bureau of Public Roads. An excerpt quotation is: "The return on this investment is made up of several forms of benefit to the public. Intangible benefits are possibly greater use of the highway at night, pleasing appearance, and greater comfort in driving, although many challenge the last benefit."

We now have the opportunity of responding to such a challenge — for the public benefit — with tangible numerical ratings for relative comfort under roadway lighting.

Professor Putnam uses the terms fluorescent and filament merely to designate, compare, and answer questions pertaining to the relative discomfort effect of two widely different luminaire sizes, under roadway lighting conditions. His Table I indicates that for individual luminaires increasing the size in length, by about five times, decreases the BCD brightness to one-third that of the smaller luminaire.

This brightness of one-third, in footlamberts, also applies to candles per square inch of projected luminaire area. Since the projected area of the larger luminaire is about five times that of the smaller, its total candlepower toward the observer can be approximately five-thirds greater, or 60 per cent higher than the candlepower from the smaller luminaire for about the same discomfort. Sixty per cent more candlepower at angles significant for pavement brightness might mean increased visibility by using the larger luminaire. Higher relative visibility with the same relative comfort-discomfort rating is one way to make progress.

Another approach that might be better would be to further reduce the brightness of the larger luminaire to keep the total candlepower the same as that from the smaller. Then the large luminaire brightness would be well below the BCD in the ratio of 3:5. Hence, the larger luminaire would be definitely more comfortable for night driving with the same total candlepower for visibility.

Table II shows that the 1:3 comparative BCD brightness, large luminaire versus the smaller, holds true for multiple sources.

Such generalities are of interest. Even more significant will be the relative comfort ratings which may be calculated for representative *systems* of roadway lighting. Such system ratings may be expressed in terms of ratio to BCD.

For example, if the visibility produced by two lighting systems is the same, one system has a discomfort rating 5:1 above BCD, the other 8:1 above BCD, then the system having the lower or 5:1 ratio would be most likely to be less objectionable to most people.

First, to develop the method, ratings will be calculated for representative roadway lighting systems using the hypothetical luminaire size, candlepower distribution, spacing, etc. We hope to have the guidance and help of Professor Putnam, Dr. S. K. Guth, the members of the I.E.R.I. Technical Advisory Committee on Light and Vision, and members of the IES Committee on Roadway Lighting.

Along the driver's path at intervals of 15 feet (0.5 MH), for distances from a luminaire up to 450 feet (15 MH), the luminaire brightness (B), solid angles (Q), viewing angles (θ), have been ready and awaiting these data for position factor, BCD, size factors, etc.

The effect on the driver of each of the several luminaires in the field of view can be properly combined for each driver position. Then the combined ratios could be averaged for a system rating.

You realize, of course, that modern roadway lighting is designed to restrict the candlepower and consequently the luminaire brightness at viewing angles near the driver's line of sight. This may be easily checked by reference to inclined plane light distribution curves showing the control of candlepower along longitudinal lines along the driver's eye-level path. Examples of such data are shown on pages 596, 597, 600, and 601, I.E., December 1955. By reference to Table II (on page 604) of the 1955 paper, the longitudinal viewing distances corresponding to Professor Putnam's angles of 10 degrees, 20 degrees, and 30 degrees may be readily checked. In many instances the top of the driver's auto windshield cuts off the brightness of luminaires at viewing angles of 30 degrees.

SYLVESTER K. GUTH:* This paper brings us one step closer to the development of a method for evaluating discomfort produced by street lighting. Furthermore, it illustrates that researches sponsored by the Illuminating Engineering Research Institute will, in the not too distant future, begin to pay important dividends to the lighting engineer.

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*General Electric Co., Lamp Division, Nela Park, Cleveland, Ohio.

The authors rightly emphasize the consistency of the trend of the data for each observer with the group average. Even though the subjective differences are large, the averaged data indicate the relative effects of the several variables which were studied. Obviously, it will be necessary to obtain data on a large group of observers in order to establish absolute values of brightness. However, this is not a particularly difficult problem once the basic relationships have been determined.

At first glance it appears that the additivity of sources for the lower field brightnesses encountered in street lighting is simpler than has been found for interior lighting conditions. However, direct additivity seems to be a function of the angular displacement of the source closest to the line of vision. Pairs of sources at 20 and 30 degrees were consistently less comfortable than pairs at 10 and 20 degrees and at 10 and 30 degrees. Thus, while direct additivity seems to be indicated, it may not be identical for various groupings of the same number of sources.

Further investigation of multiple sources may be warranted in order to develop broader generalizations. For example, a next step could be with a simulated model of typical street lighting involving the number of luminaires normally seen. This could be approached by adding sources at intermediate angles above the line of sight, such as 5, 15 and 25 degrees. By this means it should be possible to determine the influence of the source closest to the line of sight upon the additivity relationship.

In typical street lighting systems, each source or luminaire probably induces a different degree of discomfort. Does the same sort of additivity apply when the individual sensations are other than BCD?

Our ultimate aim should be elimination or minimization of discomfort. That is, the sensation should be at or less than BCD. In this study, when two or three sources were presented, the indicated brightness was from two to three times BCD — which would be considered very uncomfortable for most observers. It would seem pertinent to determine the permissible brightnesses when the groups of sources are at the BCD sensation.

In other words, as in our interior lighting BCD investigation, each new study raises almost more questions than it answers. This is a usual and normal result of research. Such a comment is not intended to deprecate the excellent work reported by the authors. It is hoped that Prof. Putnam will be able to extend this series of investigations and provide answers to these and other questions that will be asked by those who are interested in developing a sound method for evaluating discomfort glare from street and highway lighting systems.

R. G. HOPKINSON and P. PETHERBRIDGE:* Each year a valuable contribution to the literature of visual comfort comes from the Case Institute of Technology, and this year's paper by Professor Putnam and Mr. Bower covers new ground. The studies on the additive effects of glare are of special interest to us, as we also are doing work on this problem. One of us (R. G. H.) summarized the lines on which we are working and gave some preliminary results in a paper presented to the Illuminating Engineering Research Institute Symposium on Visual Research at Cornell University in 1956.[1] We, like Professor Putnam, are seeking changes in the additivity function with the brightness of the glare source and with the position of the glare source image on

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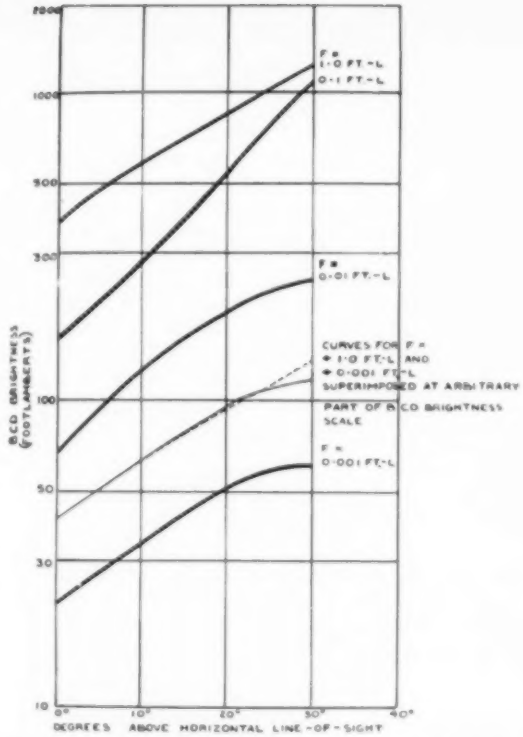

Figure A. Smoothed curves of Fig. 5, Putnam and Bower, replotted with a logarithmic scale of BCD brightness.

the retina. Unfortunately, we find that the imprecisions of subjective judgments are too great to reveal, with a satisfactory degree of certainty, the effects which we have good reason to believe exist, unless we can undertake a much greater amount of experimentation than is at present within our power. It could be argued, equally, that these effects must therefore be correspondingly of less importance in practice, if they are not easily revealed by simple experiments. To say this is not to decry the value of what Professor Putnam and his colleagues, or ourselves for that matter, are doing, but it should be remembered that the value may lie in the scientific rather than the engineering field.

We find, as does Professor Putnam, that glare sources mounted high in the field of view add up to more discomfort than would be expected from simple linear additivity. The term "super-additivity" may be given to this phenomenon, which, in the case of our own observations, appears to be confined to high brightness sources (greater than 4,000 footlamberts). None of our studies were conducted in such a way as to reveal just at what point in the peripheral field the "super-additivity" phenomenon becomes important. It seems reasonable to associate this positional effect with the change from the central retina, with a preponderance of one-to-one links between retinal elements and neural pathways, to the peripheral retina, with multi-element links with single pathways. We hope that Putnam and Bower's studies can be continued to supply more evidence on this important point.

Putnam and Bower's findings on the variation in BCD brightness with a simultaneous change in the apparent size and angular height of a glare source are confirmed by exist-

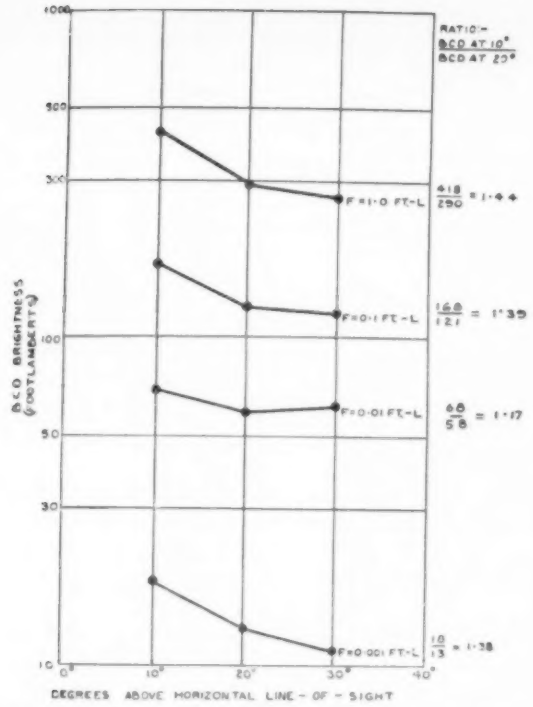

Figure B. Fig. 7, Putnam and Bower, replotted with a logarithmic scale of BCD brightness.

ing data which we have collected. On the changes which occur at about 20 degrees above the fixation point, the conclusions which can be derived from Putnam and Bower's data depend on the way in which the data are interpreted. If Figs. 5 and 7 are replotted with logarithmic scales of BCD brightness, as in the accompanying Figs. A and B (and we must here make allowances for errors introduced in our reading of low values from the figures reproduced in the preprint), then the curves for the different background brightnesses are almost identical in shape, particularly over the range up to 20 degrees. This means that if the data are interpreted in terms of *proportional*, rather than *arithmetic* increases in the BCD brightness, then the angular effect of glare does not, after all, experience such a marked transformation between 0.01 and 0.1 footlambert, or for that matter, between 0.001 and 1.0 footlambert, background brightness. We would, indeed, like to share Putnam and Bower's conclusions, but these conclusions depend on a linear rather than a proportional interpretation of the BCD values, an interpretation which we find difficult to support in the light of past experience.

We are not surprised that the sensitivity to glare of Putnam and Bowers' present group of subjects is markedly higher than that of a previous group. This is one of the things which bedevil research on visual comfort, as we have pointed out on previous occasions. The present group certainly does different considerably from that of Putnam and Gillmore's group (*e.g.* compare Fig. 5 of Putnam and Bower's paper at 0.01 footlambert with Fig. 3 of Putnam and Gillmore's paper[2]), a difference which on the multiple criterion scale amounts to more than that between "just uncomfortable" and "just acceptable." It is true, as pointed out in the present paper, that the main interest is in the trends of the observations rather than in their absolute values, but there is, nevertheless, some value in being able to compare directly, information obtained on different occasions. There is some advantage, therefore, that at the Building Research Station we are obliged to use members of the permanent staff as subjects, because we can thus maintain some continuity. In a current program of research which is being undertaken partly at the Building Research Station and partly as an Illuminating Engineering Research Institute project at Cornell University, we hope to get the best of both worlds by conducting the work in duplicate with our long-experienced B.R.S. team, and with a much larger group of students as subjects at Cornell.

We look forward to further results from Professor Putnam's laboratory, especially on the additive effect of off-axis sources, and offer any assistance within our power in the coordination of the research program.

References

1. Hopkinson, R. G.: "Evaluation of Glare," ILLUMINATING ENGINEERING, Vol. LII, No. 6, pp. 305-316 (June 1957).

2. Putnam, R. C., and Gillmore, W. F., Jr.: "Discomfort Glare at Low Adaptation Levels, II — Off-Axis Sources," ILLUMINATING ENGINEERING, Vol. LII, No. 4, pp. 226-229 (April 1957).

R. C. PUTNAM:* The authors are grateful to the discussors for their words of encouragement and helpful comments.

In an investigation such as this, involving many readings from many different observers, it is particularly interesting to find out how the results compare with other researches. For example, Mr. Faucett in his discussion brings out how well one aspect of this investigation agrees with research which he carried on at Case in 1950 and 1951, using a similar technique, but with an entirely different set of observers, having a different average value of BCD. This is shown in Fig. A of Faucett's discussion. If the curves were adjusted so that they all started from the same BCD value, the results are even more striking, as curves 1 and 3 (which were obtained experimentally) lie practically on top of one another, while curves 2 and 4 (which were plotted from equations that were developed from investigations at other surrounding brightnesses) bracket the experimental curves. Mr. Faucett's suggestion that the BCD data from the various sets of observers in the different investigations be combined to give a "standard observer" is good. Enough data are probably now available so that this may be done.

Mr. Faucett emphasizes the point that BCD is only one of several factors influencing the "seeability" in night driving. The authors are indebted to Mr. Rex for his discussion which ties in these results with the work that he and others have been doing on some of the other factors.

The authors also value Dr. Guth's encouragement and suggestions during the progress of the investigation as well as his discussion here. How true is his comment that research is never-ending.

The authors are especially appreciative of the communication of Dr. Hopkinson and Mr. Petherbridge. The fact that researchers of their international standing, working independently in another country and using somewhat different techniques, bring confirmation of some of the findings of our present investigation is very gratifying. We envy them their permanent team of long-experienced observers, as our own observers, being largely graduate students, secretaries and instructors, change from year to year. This explains the

*Co-Author.

differences in sensitivity to glare between the observers used in the investigations of Putnam and Faucett (1951), Putnam and Gillmore (1956) and the present group. With each new group of observers, however, care was taken to have them take readings that would enable them to tie in to the results of the other observers. This not only might make possible the formation of a "standard observer" as Mr. Faucett suggests, but would also facilitate cooperation with Dr. Hopkinson's group.

We welcome indeed, the offer by Dr. Hopkinson and Mr. Petherbridge for closer coordination, and assure them of our full cooperation. We know that such an exchange of ideas and results will be of mutual benefit.

In one part of the paper, reference is made to "simulated incandescent-mercury sources." It should be understood that this refers to the visual size of incandescent and mercury sources, and not to the color, as the effect of color was not considered in this investigation. This is another aspect of this very complex subject.

This investigation was sponsored by the Illuminating Engineering Research Institute, and the work was carried out under their grant No. 51.

Luminous Ceiling in a Synagogue

A radiation effect is accomplished by a baffle treatment of the luminous ceiling area in the Synagogue in the Jewish Community Centre, Ottawa, Ont. Sections of the acoustical baffles are cut in varying lengths, the ends of which describe the arc of a circle in plan view. The supports for the plastic panels are continued on with fusion strips.

The luminous ceiling is mounted 26 feet above the finished floor of the Synagogue and is suspended below a sloping structural ceiling. The system uses 48-inch rapid-start lamps mounted on a ladder system on three-foot centers.

Pews and panelling are mahogany, and the floor is covered with deep red carpeting.

Architects: Hazelgrove and Lithwick; Consulting Engineer, Vince Kozner; Lighting Specialist, Bill Fulton, Northern Electric Co., Ltd.; Electrical Contractor, Universal Electric; all of Ottawa, Ont.

Practical Daylighting Prediction

By J. W. GRIFFITH, W. J. ARNER, O. F. WENZLER

THIS PAPER presents a simplified technique for predicting daylight illumination on the work plane of rooms utilizing daylight. The method was developed for the Libbey-Owens-Ford Glass Company and is based on data collected in the daylighting laboratories at Southern Methodist University.

I. Natural Design Factors

With any daylighting installation, there are certain natural design factors that the architect or engineer has no control over. These factors are the natural sources of daylight from above the horizon and must be considered for the range of conditions that exist throughout the year.

The incident illumination from the sun, the primary source of all daylight, must be computed for the various sun altitudes and azimuths due to orientation and seasonal variation. This can be accomplished by the use of a sun angle calculator[1] and tables of average solar illumination as a function of altitude.[2] To obtain the incident illumination from the sun, the angle of incidence is computed for the particular latitude with the sun angle calculator, and the total incident illumination computed as a function of the cosine of this angle.

A secondary source of daylight illumination is the sky. The incident illumination on the fenestration from the sky may vary from clear sky conditions with the horizon brighter than the zenith to overcast sky conditions with the zenith brighter than the horizon. The illumination distribution within rooms is considerably different for clear sky and overcast sky sources. Consequently, it is necessary to compute daylight distributions in rooms for both overcast sky conditions and clear sky conditions with and without sun incident on the fenestration area depending upon the orientation of the building. The coefficients of utilization for sky conditions in this paper are based on typical overcast and clear sky patterns.[3] Tables have also been included for uniform sky conditions to be used for daylight distribution in rooms employing diffuse control. The incident illumination from typical clear sky and overcast sky patterns can be obtained from curves in the *Recommended Practice of Daylighting*.[4]

Other exterior sources of daylighting which may or may not be considered as natural sources are those which produce incident illumination on the fenestration by reflection of either direct sunlight, sky light, or both. These sources may or may not be controllable by the architect or engineer. The incident illumination from below the horizon which is ordinarily considered as ground illumination must be computed for the particular exterior terrain under the various conditions that might exist throughout the year. This can be accomplished by taking the average reflectance of the terrain, and computing the brightness due to the incident illumination from the sun and sky.

Where light reflecting areas above the horizon, such as sides of buildings or light reflecting roofs, affect the incident illumination on the fenestration or where the exterior terrain is not of uniform brightness, the incident illumination can be computed for the area source and either added to or subtracted from the total incident illumination on the fenestration. Since the daylight illumination distribution from below the horizon is considerably different from that above the horizon, and since it may be a major portion of the incident illumination,[5] the incident illumination from below the horizon must be considered separately from that above the horizon. This includes any light reflecting area below the horizon such as ground, sidewalk, or roofs below the fenestration.

II. Physical Design Factors

There are certain design factors that the architect and engineer have complete control over. For the most part these are interior factors such as room size, proportion, and reflectance. The fenestration controls can be either interior or exterior.

The interior distribution of illumination varies with both the area of the fenestration and its trans-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 9-13, 1957, Atlanta, Ga. AUTHORS: Griffith, Southern Methodist University, Dallas, Texas; Arner and Wenzler, Libbey-Owens-Ford Glass Co., Toledo, Ohio. Accepted by the Papers Committee as a Transaction of the I.E.S.

mittance. For simplification, this prediction technique uses the actual transmitting area of the fenestration rather than the area of the masonry opening, and it is based on normal sill heights. Consequently, if the area of the masonry opening is known, and the per cent reduction of transmitting area due to sash is known, the actual transmitting area can be computed or the actual transmitting area can be measured directly. Since clear glass is the most efficient and is generally used for fenestrations, the tables in this technique are based on clear glass fenestration. If glass having a transmittance other than 80 per cent from a full hemisphere is used, a ratio of this transmittance to that of clear glass must be multiplied in the computation for each prediction point. In certain areas it is necessary to add a maintenance factor into the computation of illumination on the work plane due to excessive dirt collection on the glass. Under most conditions, the maintenance factor approximates one, and for comparative purposes it is not necessary to include in computations.

Since the daylighting distribution for multilateral fenestration areas varies according to the incident illumination on each fenestration area, the total daylight distribution is not proportional to any one incident illumination value. Consequently, it is necessary to compute the illumination distribution for each fenestration, and add the result for the total distribution. Since daylighting distribution is asymmetric from a single fenestration area, it is necessary to predict illumination at various locations so that a distribution curve across the room can be obtained. As in previous papers,[6] prediction points have been located on a center line perpendicular to the fenestration on a 30-inch work plane. The maximum point is located 5 feet from the fenestration area, the mid-point is in the middle of the room, and the minimum point is located 5 feet in from the wall opposite the fenestration area. These points permit prediction of multilateral daylighting design.

The daylight illumination distribution at each point varies with the length, width, ceiling height, and room reflectances. The amount of variation due to one of these factors is dependent upon the others so that no one factor can be isolated from the inter-relation. Consequently, it is necessary to obtain a factor which takes into account the relation between the ceiling height, the wall reflectances, and the width of the room. It is also necessary to obtain factors which take into account the inter-related effect of the length, width, and the wall reflectances. For simplification in this paper, the coefficient of utilization is combined with the factors relating to the length, width, and wall reflectance. Wall reflectances in rooms may vary over a range of from 30 per cent to 70 per cent. Tables have been developed for these values, and values for other wall reflectances may be computed by straight line interpolation. These tables are based on rooms having a ceiling reflectance of 80 per cent and a floor reflectance of 30 per cent. Large variations in floor reflectance produce only small variations in illumination distribution; therefore, the tables are applicable to most floor reflectances.

A further design factor is that of fenestration control. If the fenestration has no controls, illumination distribution is based on the total incident illumination and the appropriate values from the tables. If a diffuse control such as a fully drawn shade is employed, the daylight distribution is based on the total incident illumination and the transmission factor of the diffuse control. It is computed as follows. Half of the total incident illumination is treated as coming from a uniform sky and half from the ground. If the control is not perfectly diffusing, it is necessary to obtain a light distribution curves for a sample of the control medium, and apply a weighted factor for the particular sun condition being analyzed.

III. A Simplified Prediction Technique

This prediction technique is based on the total incident illumination on the fenestration area from above the horizon and from below the horizon. Since the distribution of illumination from above the horizon is considerably different from that below the horizon, it is necessary to compute the illumination on the work plane for each condition and add the results. This is accomplished by predicting the work plane illumination at the three points previously described as the maximum, mid-point, and minimum point for incident illumination from above and below the horizon.

To predict the illumination at each design point in the room, it is necessary to obtain a coefficient of utilization for incident illumination at this point. For simplification this coefficient of utilization has been incorporated into the table of factors for variations due to the combined effect of the room length to width ratio in conjunction with wall reflectance. A further factor to be considered is the combined effect of the ceiling height in conjunction with the width of the room and the wall reflectance. Consequently, the work plane distribution of illumination is obtained by computing the illumination at each point for incident illumination from above the horizon and for that from below the horizon using the following equation:

$$E_{wp} = E_i \times A_f \times C.U. \times K_c$$

where

E_{wp} = The work plane illumination for a particular point

E_i = The incident illumination on the fenestration from either the sky (E_{is}) or the ground (E_{ig})

A_f = The light transmitting area of the fenestration

$C.U.$ = The coefficient of utilization (combined with the effect of length and width)

K_c = A factor of variation due to the ceiling height in conjunction with the width of the room.

If daylighting predictions are computed for areas where heavy dirt collection on the fenestration might lower the work plane illumination, a maintenance factor should be included in the equation.

Tables I through IV are used to obtain the coefficient of utilization from the various sources with the particular room dimension and wall reflectance under study. Tables V through VIII are used to obtain the K_c factor for the various incident illumination conditions for the particular ceiling height, width, and wall reflectance. Where the specific condition under study is not covered by the tables, straight line interpolation may be used to obtain the necessary factors.

TABLE I — Coefficients of Utilization for Overcast Sky with No Control on the Fenestration.

Wall Reflectance	Width	20-ft Length		30-ft Length		40-ft Length	
		70%	30%	70%	30%	70%	30%
MAX	20	.0248	.0226	.0172	.0156	.0129	.0123
	30	.0245	.0223	.0169	.0155	.0123	.0118
	40	.0242	.0221	.0164	.0154	.0120	.0117
MID	20	.0143	.0105	.0091	.0078	.0073	.0064
	30	.0052	.0045	.0049	.0036	.0031	.0030
	40	.0035	.0024	.0027	.0021	.0020	.0017
MIN	20	.0078	.0048	.0057	.0039	.0045	.0033
	30	.0029	.0017	.0026	.0015	.0018	.0013
	40	.0017	.0008	.0014	.0008	.0011	.0007

TABLE II — Coefficients of Utilization for Uniform Sky with No Control on the Fenestration.

Wall Reflectance	Width	20-ft Length		30-ft Length		40-ft Length	
		70%	30%	70%	30%	70%	30%
MAX	20	.0222	.0195	.0157	.0137	.0115	.0108
	30	.0217	.0193	.0149	.0136	.0108	.0104
	40	.0213	.0191	.0145	.0135	.0106	.0102
MID	20	.0152	.0110	.0099	.0083	.0080	.0069
	30	.0070	.0054	.0060	.0043	.0040	.0037
	40	.0046	.0030	.0035	.0025	.0026	.0022
MIN	20	.0097	.0059	.0072	.0047	.0057	.0042
	30	.0042	.0023	.0038	.0021	.0026	.0018
	40	.0024	.0012	.0020	.0011	.0016	.0010

TABLE III — Coefficients of Utilization for Clear Sky with No Control on the Fenestration.

Wall Reflectance	Width	20-ft Length		30-ft Length		40-ft Length	
		70%	30%	70%	30%	70%	30%
MAX	20	.0185	.0156	.0129	.0111	.0099	.0088
	30	.0183	.0156	.0123	.0108	.0088	.0083
	40	.0180	.0151	.0118	.0107	.0086	.0082
MID	20	.0138	.0094	.0090	.0071	.0075	.0060
	30	.0074	.0049	.0056	.0039	.0041	.0033
	40	.0047	.0029	.0036	.0025	.0026	.0021
MIN	20	.0095	.0054	.0071	.0044	.0060	.0039
	30	.0049	.0025	.0042	.0021	.0029	.0019
	40	.0028	.0013	.0024	.0012	.0019	.0011

TABLE IV — Coefficients of Utilization for Uniform Ground with No Control on the Fenestration.

Wall Reflectance	Width	20-ft Length		30-ft Length		40-ft Length	
		70%	30%	70%	30%	70%	30%
MAX	20	.0132	.0101	.0092	.0079	.0073	.0064
	30	.0127	.0101	.0088	.0079	.0069	.0063
	40	.0123	.0101	.0084	.0077	.0065	.0062
MID	20	.0115	.0081	.0085	.0064	.0066	.0054
	30	.0075	.0051	.0056	.0043	.0045	.0037
	40	.0050	.0033	.0040	.0030	.0029	.0023
MIN	20	.0095	.0064	.0074	.0049	.0060	.0040
	30	.0046	.0023	.0037	.0021	.0030	.0019
	40	.0026	.0016	.0023	.0011	.0020	0010

TABLE V — Ceiling-Width Variable (K_c) for Overcast Sky with No Control on the Fenestration.

Ceiling Height / Wall Reflectance	Width	8 feet 70%	8 feet 30%	10 feet 70%	10 feet 30%	12 feet 70%	12 feet 30%	14 feet 70%	14 feet 30%
MAX	20	.125	.129	.121	.123	.111	.111	.0991	.0973
	30	.122	.131	.122	.121	.111	.111	.0945	.0973
	40	.145	.133	.131	.126	.111	.111	.0973	.0982
MID	20	.0908	.0982	.107	.115	.111	.111	.105	.122
	30	.105	.102	.0939	.113	.111	.111	.121	.134
	40	.106	.0948	.123	.107	.111	.111	.135	.127
MIN	20	.0908	.102	.0951	.114	.111	.111	.118	.134
	30	.0924	.119	.101	.114	.111	.111	.125	.126
	40	.111	.0926	.125	.109	.111	.111	.133	.130

TABLE VI — Ceiling-Width Variable (K_c) for Uniform Sky with No Control on the Fenestration.

Ceiling Height / Wall Reflectance	Width	8 feet 70%	8 feet 30%	10 feet 70%	10 feet 30%	12 feet 70%	12 feet 30%	14 feet 70%	14 feet 30%
MAX	20	.145	.154	.123	.128	.111	.111	.0991	.0964
	30	.141	.151	.126	.128	.111	.111	.0945	.0964
	40	.159	.157	.137	.127	.111	.111	.0973	.0964
MID	20	.101	.116	.115	.125	.111	.111	.101	.110
	30	.0952	.113	.105	.122	.111	.111	.110	.122
	40	.111	.105	.124	.107	.111	.111	.130	.124
MIN	20	.0974	.111	.107	.121	.111	.111	.112	.119
	30	.0956	.125	.103	.117	.111	.111	.115	.125
	40	.111	.105	.125	.111	.111	.111	.133	.124

TABLE VII — Ceiling-Width Variable (K_c) for Clear Sky with No Control on the Fenestration.

Ceiling Height / Wall Reflectance	Width	8 feet 70%	8 feet 30%	10 feet 70%	10 feet 30%	12 feet 70%	12 feet 30%	14 feet 70%	14 feet 30%
MAX	20	.145	.155	.129	.132	.111	.111	.101	.0982
	30	.141	.149	.125	.130	.111	.111	.0954	.101
	40	.157	.157	.135	.134	.111	.111	.0964	.0991
MID	20	.110	.128	.116	.126	.111	.111	.103	.108
	30	.106	.125	.110	.129	.111	.111	.112	.120
	40	.117	.118	.122	.118	.111	.111	.123	.122
MIN	20	.105	.129	.112	.130	.111	.111	.111	.116
	30	.0994	.144	.107	.126	.111	.111	.107	.124
	40	.119	.116	.130	.118	.111	.111	.129	.118

TABLE VIII — Ceiling-Width Variable (K_c) for Uniform Ground with No Control on the Fenestration.

Ceiling Height / Wall Reflectance	Width	8 feet 70%	8 feet 30%	10 feet 70%	10 feet 30%	12 feet 70%	12 feet 30%	14 feet 70%	14 feet 30%
MAX	20	.124	.206	.140	.135	.111	.111	.0909	.0859
	30	.182	.188	.140	.143	.111	.111	.0918	.0878
	40	.124	.182	.140	.142	.111	.111	.0936	.0879
MID	20	.123	.145	.122	.129	.111	.111	.100	.0945
	30	.0966	.104	.107	.112	.111	.111	110	.105
	40	.0790	.0786	.0999	.106	.111	.111	.118	.118
MIN	20	.0994	.108	.110	.114	.111	.111	.107	.104
	30	.0816	.0822	.0984	.105	.111	.111	.121	.116
	40	.0700	.0656	.0946	.0986	.111	.111	.125	.132

IV. Reliability of Practical Daylighting Predictions

Unfortunately there are practically no published daylighting surveys where enough data has been taken to make comparisons with predicted values. It appears from data taken at Southern Methodist University that the predicted values are within 20 per cent of measured values.

Example No. 1

Predict the work plane illumination for a room 30 feet x 30 feet x 12 feet with a 3.5-foot sill and a window wall of metal sash having a clear opening of 80 per cent. The ceiling reflectance is 80 per cent, the wall reflectance is 70 per cent, and the floor reflectance is 30 per cent. The exterior conditions are an overcast sky with 636 footcandles incident from the sky and 96 footcandles incident from the ground. These are the conditions of an actual test taken October 6, 1952, at 4:00 p.m. in a full size test house.

Step 1. Compute the actual light transmitting fenestration area (A_f).

$A_f = 30 \text{ feet} \times 8.5 \text{ feet} \times .8 = 204 \text{ square feet}$

Step 2. Obtain the Coefficients of Utilization (*C.U.*) for each point using Tables I and IV.

Overcast Sky	Uniform Ground
C.U. Max. = .0169	*C.U.* Max. = .0088
C.U. Mid. = .0049	*C.U.* Mid. = .0056
C.U. Min. = .0026	*C.U.* Min. = .0037

Step 3. Obtain the K_c factor for each point using Tables V and VIII.

The K_c factors of each point from both the sky and ground conditions are .111. This is due to the fact that these factors are based on rooms with 12-foot ceiling heights.

Step 4. Compute the work plane illumination at each point for the sky condition using the equation: $E_s = E_{is} \times A_f \times K_c \times C.U.$

E_s Max. = (636) (204) (.111) (.0169) = 243
E_s Mid. = (636) (204) (.111) (.0049) = 70.6
E_s Min. = (636) (204) (.111) (.0026) = 37.4

Step 5. Compute the work plane illumination at each point for the ground condition using the equation: $E_g = E_{ig} \times A_f \times K_c \times C.U.$

E_g Max. = (96) (204) (.111) (.0088) = 19.1
E_g Mid. = (96) (204) (.111) (.0056) = 12.2
E_g Min. = (96) (204) (.111) (.0037) = 8.0

Step 6. Add the work plane illumination from the sky and ground to obtain the total work plane illumination (E_t) for each point.

	Computed fc	Measured fc
E_t Max. = 243 + 19.1 =	262	282
E_t Mid. = 70.6 + 12.2 =	83	78
E_t Min. = 37.4 + 8.0 =	45	48

Example No. 2

Predict the work plane illumination for a room 30 feet x 24 feet x 12 feet with a 3.5-foot sill and a window wall of metal sash having a clear opening of 80 per cent. The ceiling reflectance is 80 per cent, the wall reflectance is 60 per cent and the average floor reflectance is 35 per cent. The exterior conditions are a clear sky with 2483 foot-candles incident on the fenestration from the sun, sky and ground. The fenestration is covered by a shade cloth having a 10 per cent transmittance. These are similar conditions to that of a test taken on May 7, 1949 at 2:30 p.m. in a full-size test house oriented South.

Step 1. Compute the actual light transmitting fenestration area (A_f).

A_f = 30 feet × 8.5 feet × .8 = 204 square feet

Step 2. Obtain the Coefficients of Utilization *(C.U.)* for each point using Tables II and IV.

Uniform Sky	Uniform Ground
C.U. Max. = .0150	*C.U.* Max. = .0087
C.U. Mid. = .0079	*C.U.* Mid. = .0069
C.U. Min. = .0053	*C.U.* Min. = .0054

Step 3. Obtain the K_c factor for each point using Tables VI and VIII.

The K_c factors of each point from both the sky and ground conditions are .111. This is due to the fact that these factors are based on rooms with 12-foot ceiling heights.

Step 4. Compute the work plane illumination at each point for a uniform sky condition using the equation:

$$E_s = E_{is} \times A_f \times K_c \times C.U.$$

E_{is} is obtained by taking half of the total incident illumination and multiplying it by the transmittance of the diffuse shade (10 per cent).

$$\frac{2483}{2} \times .1 = 124$$

E_s Max. = (124) (204) (.111) (.0150) = 42
E_s Mid. = (124) (204) (.111) (.0079) = 22
E_s Min. = (124) (204) (.111) (.0053) = 15

Step 5. Compute the work plane illumination at each point for a uniform ground using the equation:

$$E_g = E_{ig} \times A_f \times K_c \times C.U.$$

E_{ig} is equal to E_{is} (124)

E_g Max. = (124) (204) (.111) (.0087) = 24
E_g Mid. = (124) (204) (.111) (.0069) = 19
E_g Min. = (124) (204) (.111) (.0054) = 15

Step 6. Add the work plane illumination from the sky and ground to obtain the total work plane illumination (E_t) for each point.

	Computed fc	Measured fc
E_t Max. = 42 + 24 =	66	74
E_t Mid. = 22 + 19 =	41	44
E_t Min. = 15 + 15 =	30	30

V. Conclusions

1. This is a practical and simplified method for predicting the work plane distribution of daylight through clear glass fenestrations. It is directly applicable to fenestrations with overcast sky or clear sky conditions with no sun incident on the fenestration. Where sun is incident on the fenestration, this prediction technique may be used if diffuse controls are employed. This is accomplished by using the uniform sky tables in conjunction with the uniform ground tables.

2. This technique permits the prediction of multilateral daylighting design by investigating each

fenestration independently. It is a companion to the daylight prediction method for adjustable horizontal louvers.[7]

3. This paper presents one of a series of daylight prediction techniques being developed for the Libbey-Owens-Ford Glass Company. The full series will cover most of the practical daylighting designs, thus enabling the architect and illuminating engineer to compare alternate designs under a variety of natural conditions. It will also permit integration of daylighting and artificial lighting designs.

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DISCUSSION

E. W. CONOVER:* Since my company participated in the program which provided the basic data for this paper, it is only natural that we should present our comments.

We wish to compliment the authors on providing a method considerably simpler than that given in the lumen method paper presented at the 1954 Conference of the Society. It is clear, concise and well organized.

In the test program, the windows for practically all tests were continuous from wall to wall. We find no mention of this in the paper, but note that the window area is mentioned in such a way as to imply that the system will apply to any size or location of the window in the sidewall. We doubt its application to a single window or even a strip window with a fairly high sill height and with lintel down several feet from the ceiling.

At the close of the program at Southern Methodist University, we also developed a simplified method called the Fenestra Method which has a different approach to the problem. Using our method, we predicted the results for the two examples given in the paper, and were pleased to find a reasonably close check. In example No. 1, we secured 264, 84 and 45 footcandles for the maximum, mid-point and minimum points. For example No. 2, our method gave 64, 39 and 25.

Time has not permitted further checks, but we believe that strength would have been added if results secured by the lumen method were included.

We note that this paper is only one of a series that will cover other features of daylighting design. It is hoped that the complete series will be published soon so that further checks with the Fenestra Method can be made.

*Fenestra, Inc., Detroit, Mich.

D. E. SPENCER:* The design procedures given by the authors are of distinct practical value. They fill the place for daylighting which the original empirical coefficients of utilization of Harrison and Anderson fill for artificial lighting.

However, they do not preclude the need for a theoretical foundation of the problem. The interflection method should still be extended to the daylighting problem for two reasons.

(1) The distribution of quantity of light throughout the room should be obtainable for all fenestrations and weather conditions on both horizontal and vertical surfaces.

(2) The appearance of the luminous environment should also be predictable for all room shapes and reflectances.

Until the entire luminous environment can be specified and analyzed, not only as to quantity of light, but also as to the adaptation for all possible lines of sight, there will not be an adequate scientific basis for the design of daylighted interiors. Meanwhile, empirical attacks are welcome and valuable.

J. W. GRIFFITH:** It is gratifying to see that the Fenestra Method of daylighting design correlates with the prediction technique outlined in this paper. The technique was not designed to cover all conditions of daylighting design. It was designed to predict the daylight illumination for daylighting designs that are considered acceptable today. Consequently, the single window or any fenestration that obviously does not produce adequate daylighting is not covered by this prediction technique.

We quite agree with Dr. Spencer and hope the interflection method for daylighting will be forthcoming in the future. The distribution of daylight throughout the room for all fenestrations and weather conditions on both horizontal and vertical surfaces could be obtained by empirical techniques if time and personnel were available to undertake the study. Such an approach is both time consuming and expensive. Possibly a theoretical approach will prove more economical in the final analysis.

*University of Connecticut, Storrs, Conn.
**Co-Author.

I.E.S. Emblem

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Daylight PLUS Electric Light—In Schools

By H. S. GREGORY

ADVANTAGES in use of daylight for school lighting are well known — it is economical and usually available in large quantities. But many lighting problems can result from the efforts of architects to depend on daylighting extensively in school buildings. It is not a dependable source, it produces great amounts of glare if not properly controlled, and it is difficult to control without reducing the quantities drastically. These were the facts finally faced by the architects for the Bogalusa, La., High School.

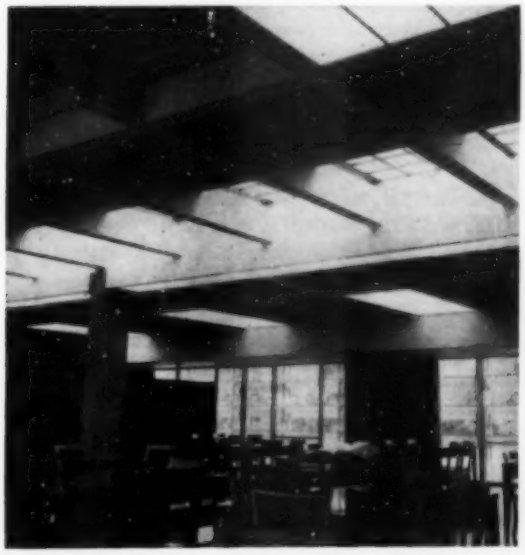
Large glass areas had been worked into the design of the school buildings, with entire side walls of classrooms made of glass. Permanent structural louvers are used on sides exposed to direct sunlight, but large unshielded areas are still exposed to the field of view. Properly designed electric lighting was called for to neutralize contrast.

The most difficult lighting problem was in the library, where daylighting was by an arrangement of skylights and window walls. The library is 50 feet by 60 feet in size, with glass walls on each side and two large skylights down the center.

Using daylight only, on bright sunny days a pattern of alternate bright and dark areas would produce undesirable brightness ratios, and on dark cloudy days there would be very little illumination. Solution to both these conditions had to be found in a single lighting installation — without change in the architectural appearance of the room.

To light the dark sections between the skylights and window walls, artificial skylights were constructed in recessed areas formed by the open concrete beams. These are 4 feet by 9 feet and each is equipped with twelve four-foot 40-watt rapid-start single lamp strips. They are shielded with low-

AUTHOR: Gregory-Salisbury & Co., New Orleans, La.; architects, Burk, LeBreton & Lamantia; Consulting Electrical Engineers, Louis N. Goodman & Associates, also of New Orleans. This installation won first prize in the New Orleans Section's contest, and in the South Central Regional My Most Interesting Lighting Job contest.



Daylight plus electric light as used in the library. Photos, processed from colored slides, do not accurately depict brightness contrasts, but show techniques used.

Home economics room, where four rows of shielded luminaires provide 50 footcandles at center of room.

Gymnasium, where illumination from closely-spaced incandescent units reduces apparent brightness of walls.

brightness, plastic, egg-crate louvers with 45- by 45-degree cut-off. A level of 80 footcandles is supplied by these artificial skylights, making a total of 175 footcandles with daylight at noon on a sunny day. This is sufficient to offset the high level at the window wall, and on gloomy days is adequate and comfortable for the area served.

But what of the center area on a gloomy day? Very little light would come from the daylighting skylights and the artificial skylights are too far away to help. A specially designed surface troffer was installed on the bottom of the beam between the two skylights, reinforcing the structural appearance of the room. Two rows of rapid-start lamps with reflectors are used in the troffer, and shielding is provided by plastic egg-crate louvers with 45- by 45-degree cut-off.

This electric lighting system blends with the architectural design in that where there were skylights there are now more skylights, where there were beams, one expanded beam has been added.

On the north side of one building, the home economics room has an unshielded glass wall open to the sky. Here 50 footcandles are provided in the center of the room by four rows of well-shielded luminaires. Without the electric lighting, the level at the center of the room is 8 footcandles, in contrast with the 150-200 footcandles on desks near the window. In a science lecture room, similarly, without additional light, daylighting provides a range of from 10 to 200 footcandles, a ratio of 1 to 20. With electric illumination added, levels varied from 70 to 240 across the room, a ratio of 1 to 3½.

In the gymnasium, 150 footcandles are provided, at the center of the floor, by closely-spaced 1000-watt bowl silvered diffusers with upward component. This greatly reduces the apparent brightness of the glass walls.

Similar treatment was applied in the Manual Arts Building corridors, and other classrooms — wherever comfort demanded electric lighting in addition to that supplied by daylighting.

I.E.S. Officer and Committee Personnel

Listings of the I.E.S. National and Local Officers and personnel of Standing, General, Task and Technical Committees begin on pages 42A and 31A, respectively, this issue.

Analysis of Light Distributions from Linear Source Street Luminaires

By ROBERT G. McPHAIL

UNTIL RECENTLY all street lighting units were round. Technically, they were composed of surfaces of revolution about a vertical axis, and the light source — generally assumed to be a point — was located somewhere on this axis. Such a unit produced a circular distribution of light, which showed up as a circle on the street. If there were defects in the design, then light and dark circles would appear on the street. A circular light pattern was not particularly efficient in illuminating a rectangular roadway area. Still it could be used.

The next step in the development of street luminaires was the round asymmetric type. It still had basically a circular pattern, but the light was laterally concentrated to put it on the street where it was useful. A conventional diagram of the distribution of light from such a unit is shown in Fig. 1. Notice that it is made up entirely of radial lines and arcs of circles, and notice also that it does not fit the rectangular geometry of the street particularly well. Nevertheless, units of this type are doing a creditable job of illuminating our streets and highways, and will doubtless continue to do so for a long time.

About ten years ago a horizontally mounted mercury lamp in an oval shaped unit was introduced. This was a more revolutionary step than most of us realized at the time, for by eliminating the vertical axis of symmetry we had developed a luminaire whose distribution could no longer be analyzed by the presently accepted circular coordinate system of cones of maximum candlepower and vertical planes. By trying to make the distribution of such luminaires fit circular coordinates, we discovered that they produced not circular distributions but rectangular distributions in the form of a plane through the long axis of the source, and that nothing we could do would alter this fact.

Perhaps a word of explanation as to why this should be true is in order. Suppose one took any of the horizontal street luminaires using a mercury lamp and painted the whole reflector black except for a very small area, say a quarter inch circle in the beam section (that section sending light at high vertical angles). This spot would reflect a lamp image on the street. If the lamp were horizontal the image would look like a bright line across the street perpendicular to the curb. If a section of a refractor with prisms is now fastened to the reflector to intercept this spot of beam light, the lamp image will be moved to some new location, but will still be a line perpendicular to the curb.

If instead of blackening the reflector a black paper were put over the refractor with a single small hole over the prisms, the result would be exactly the same — a bright line across the street. Now reflectors and refractors can be considered as being made up of a large number of such small elements, and since each small element lays down a line of light perpendicular to the curb, the total resultant pattern must be a line or series of lines perpendicular to the curb. In actual practice these series of lines from the small elements are made to fall on top of each other to form one line, in order to get as much light as possible at high angles (beam direction) and to make the above beam cutoff as sharp as possible.

The fact that when a horizontally mounted linear light source is used a rectangular light pattern will inevitably result brings up two questions. First, is it suitable for lighting a street? The answer is

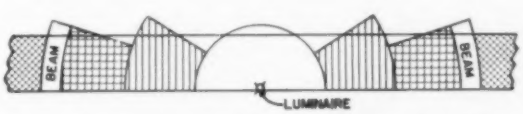


Figure 1. Plan view of street showing the distribution from a round luminaire.

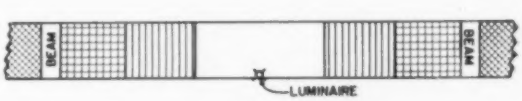


Figure 2. Plan view of street showing a rectangular distribution.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 9-13, 1957, Atlanta, Ga. AUTHOR: Holophane Company, Inc., Newark, Ohio.

an emphatic "yes." Fig. 2 shows schematically how a rectangular line pattern fits the street much better than the circular pattern shown on Fig. 1.

The second question is whether a method of analysis for such a rectangular pattern can be devised which will fit the pattern better than the presently used circular system. The answer is again "yes." In fact Hogner[1] discussed the basis for such a system in a paper published in 1910. Other contributions to this subject have been made from time to time,[2] so that by collecting and putting together the bits and pieces it is possible to form an integrated system. Such a system must provide methods of finding candlepower in planes (through the source) crosswise or lengthwise of the street and luminous flux in the zones bounded by such planes. From these values all other data such as brightness, veiling glare, utilization, and vertical and horizontal footcandles can be calculated.

In order to simplify the development and description of such a system, let us assume for the remainder of the paper that all streets extend east and west and that street luminaires are always mounted on the south side of the street. Angles across the street can be called NORTH angles, designated by the letter N, and angles along the street EAST angles, designated by the letter E. Fig. 3 shows the N and E angles graphically, also the corresponding L and V angles of the conventional system.

The point "a," Fig. 3, has rectangular coordinates of $N = 30°$, $E = 50°$. Its conventional coordinates are $L = 64°$, $V = 53°$. The formulae used for this calculation are:

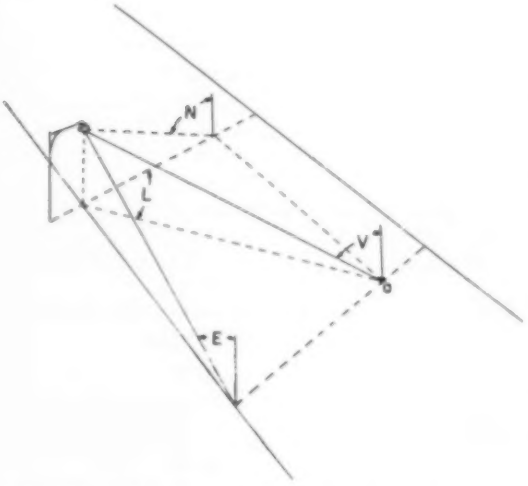


Figure 3. Relationship of N and E angles to L and V angles.

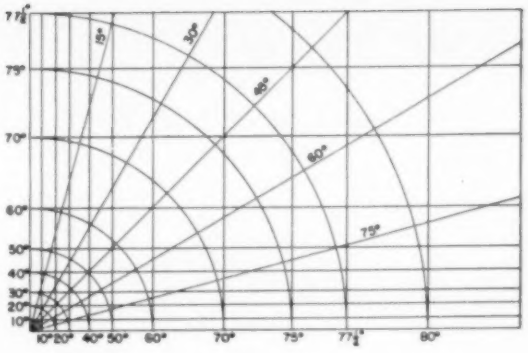


Figure 4. Plan view of street showing both circular and rectangular coordinate grids.

$$\text{Tan } L = \frac{\text{Tan } E}{\text{Tan } N} \qquad \text{Tan } V = \frac{\text{Tan } N}{\text{Cos } L}$$

There are other formulae for finding these relations, but probably the easiest method is to make a comparatively large chart of a horizontal area to be lighted, on which both rectangular (N and E) and polar (L and V) grids are plotted, like Fig. 4. A take-off from such a chart is sufficiently accurate for most purposes.

The reason that this simple transformation has been considered in such detail is that most photometers are so made that they can be set only to L and V coordinates. Thus by this transformation it is possible to measure the candlepower at any N and E angles by the proper selection of L and V angles. It is possible to measure the candlepower in a number of planes and thus get a true picture of the distribution from the luminaire. These planes may be E planes (for example, $E = 72°$) to get a true picture of the beam from the luminaire, or they may be N planes to describe the distribution along the length of the street. Rex[2] calls such planes "slant planes."

It is convenient to calculate other quantities with the photometric data taken in N and E planes; for example, the formula for calculating horizontal illumination in N and E terms is:

$$E = \frac{I}{h^2} \frac{\text{Cos}^3 N \text{ Cos}^3 E}{\text{Cos}^3 X}$$

where $X = \text{Sin}^{-1} \text{Sin} N \text{ Sin} E$

One way to avoid the use of this rather formidable formula is to reconvert the N and E coordinates of the various points to V coordinates (the L angles are not necessary) and calculate by means of the classic formula, $E = \frac{I}{h^2} \text{Cos}^3 V$.

Another way of calculating illumination is to

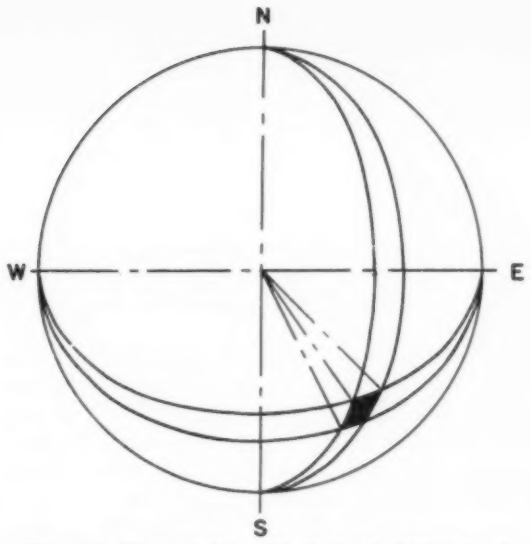


Figure 5. Diagram for method of calculating zonal factors.

divide the lumens in each rectangle on the street made by the N and E grid by the area of the rectangle. This, of course, gives the average lumens per square foot in the rectangle. But before this can be done some method must be given for finding the lumens in each rectangle.

The lumens incident on any rectangle on the street can be found by using the same basic concept of the unit sphere, as is presently used for calculating zonal lumens. Only the grid on the sphere need be changed. According to present procedure, the surface of the unit sphere is divided into zones or bands bounded by parallels. Candlepower readings are made at the center of each zone and multiplied by the area of the zone in steradians to give the lumen output from that zone. This procedure may be followed to determine the lumens in various N and E zones; the only difference is that the area of the N zone is bounded by meridians with the axis of the poles running in an east-west direction, and the E zones are bounded by meridians with the axis of the pole running in a north-south direction. The intersection of the N zone and the E zone form an increment shown darkened in Fig. 5.

Hogner developed a formula for calculating the zone factor for the increment at the intersection of the N and E zone, which was reprinted in Higbie's[3] "Lighting Calculations" on pages 67 through 69, together with a table of zone factors for 10° increments of N and E.

Hogner's formula, however, is unnecessarily complicated. If one wished to find the area "a" of the rectangle 1-2-3-4 in Fig. 6, he would probably use the formula:

$$a = (l_2 - l_1)\,(w_2 - w_1)$$

An easier method, however, would be as follows:

$$\begin{aligned} \text{Let}\quad a_1 &= w_1 l_1 \\ a_2 &= w_1 l_2 \\ a_3 &= w_2 l_1 \\ a_4 &= w_2 l_2 \end{aligned}$$

Then the area $a = [(a_1 + a_4) - (a_2 + a_3)]$.

This formula might prove handy if a number of contiguous rectangles are to be figured, because each "a" is common to four rectangles.

Now to find the area of the quadrilateral on the unit sphere through which the light comes that illuminates the rectangle 1-2-3-4 on the street, we use the general formula:

$$\operatorname{Sin} X = \operatorname{Sin} N \operatorname{Sin} E$$

Let:

$$\begin{aligned} X_1 &= \operatorname{Sin}^{-1}(\operatorname{Sin} N_1 \operatorname{Sin} E_1) \\ X_2 &= \operatorname{Sin}^{-1}(\operatorname{Sin} N_1 \operatorname{Sin} E_2) \\ X_3 &= \operatorname{Sin}^{-1}(\operatorname{Sin} N_2 \operatorname{Sin} E_1) \\ X_4 &= \operatorname{Sin}^{-1}(\operatorname{Sin} N_2 \operatorname{Sin} E_2) \end{aligned}$$

The solid angle of the spherical quadrilateral, the zone factor for this zone, is then:

$$Zf = \frac{\pi}{180}\,[(X_1 + X_4) - (X_2 + X_3)]$$

When the zone factors have been found it is only necessary to multiply them by the mid-zone candlepower, or the average zone candlepower, however determined, to find the lumen output in that zone. From this the utilization can easily be calculated by adding the outputs of the appropriate zones. The average illumination in any zone can be found

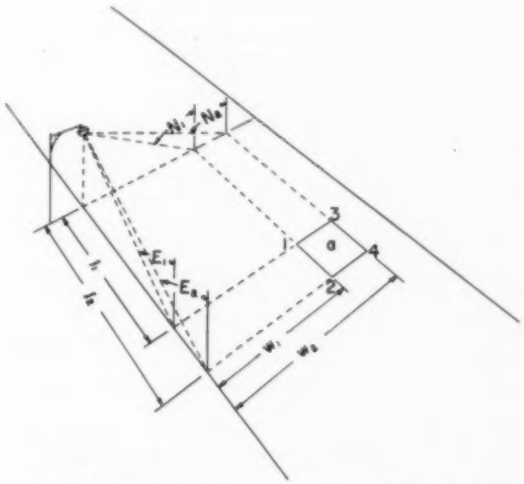


Figure 6. Point "a" of Fig. 3 expanded into a finite square.

by dividing the zone lumens by the area of the zone in square feet.

By using this method of slant planes instead of vertical planes and cones it is possible to analyze the distribution of a luminaire with rectangular distribution in a way which makes sense. Distribution curves in *E* planes show an actual beam, not a diagonal cross section of it, and curves in *N* planes show the distribution of light in the lanes along the street followed by the motorist. Rex[2] has shown how brightness data, veiling glare, and comfort evaluations according to various systems can be obtained from these data. In his studies he has used equal area zones, which, of course, results in unequal increments of *N* and *E*. For some applications we prefer to use equal increments of *N* and *E*. Our experience has shown both systems have advantages and disadvantages, and either will give satisfactory results.

Now comes the dilemma, which is the chief reason for this paper. We have street luminaires which produce a rectangular distribution of light — an entirely satisfactory distribution for lighting a street. The American Standard Practice for Street and Highway Lighting, however, was written before linear sources were in general use. It was written in terms of circular coordinates, and while this coordinate system is perfectly suitable for point sources in round luminaires, it is often misleading in describing rectangular distributions.

For example, in Fig. 7 we can see that if the rectangular beam shown is tested in a, say 75° cone, the data will indicate a much narrower beam than we actually have. The 75° cone will cut through the rectangular beam near its center. If a lower cone were tested it would cut through the beam near the curb line, while a higher cone would cut through farther across the street. There could be any number of points in the rectangular beam pattern that could be chosen as the test cone. For each point there would be different vertical and lateral angles of maximum candlepower. These

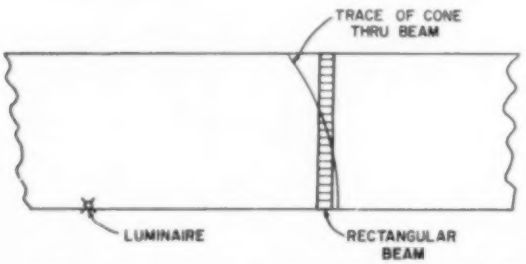


Figure 7. Arc of circle represents cone as it would cut diagonally through a rectangular beam.

would be the basis of determining I.E.S. distribution types. But, which would be correct?

One way out of this difficulty would be to add to the present recommended practice a section for units with rectangular distribution written in terms of planes instead of cones. Another possibility would be to retain the present Types I, II, etc., classifications, but base them on actual street geometry rather than angular width of luminaire distribution (whether taken in planes or cones). Such values could logically be based on street width to mounting height ratios.

But such a change, whether it be simply adding to the present recommended practice or making small modifications of it, would take care of only the immediate difficulty. At this point it might be proper to suggest a few other possible revisions of the recommended practice based on the view-point of a street lighting design engineer. Who knows what form future street lighting developments may take? Shall a new set of classifications be developed for each new engineering development? Should the classification not be made broad enough to cover any satisfactory street lighting device or method? Instead of being based on light distributions, could they not be based on illumination on the street — however obtained?

Immediately another complex problem presents itself. What is the ideal distribution of illumination on a street? Recently there has been considerable research on this subject — very excellent research; but the results to date have served merely to confuse the issue. They have proved that the answer is not as simple as it seemed to be, and that much more study is required before a clear-cut statement of the optimum distribution can be made. It is even possible that no such statement can ever be made and that a final recommendation will be so full of compromises as to be always subject to controversy. Nevertheless, there are some characteristics of street lighting which everyone agrees are desirable and others that everyone agrees are undesirable. The practical specification for illumination of streets could be based on such generally accepted criteria.

The first requirement of a street light is to light the street, including side walks where applicable, for any light not sent directly onto this area can be considered lost. Other things being equal, the more light (coefficient of utilization) a luminaire puts on the roadway the better the luminaire.

The second requirement is that the illumination cover the roadway area reasonably uniformly. There should be no bright and dark areas and no conspicuous streaks or striations. Any motorist

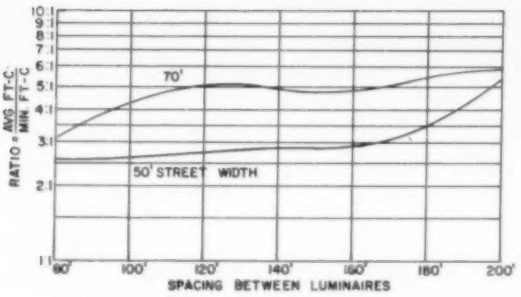


Figure 8. Typical uniformity ratio curve.

who has driven under poorly designed street lighting knows how disconcerting and even dangerous light and dark areas can be and how annoying it is to see bumps and obstacles ahead, only to find on closer approach that they are nothing but light and dark streaks from the luminaire.

In some ways these two requirements conflict. The highest coefficient of utilization could be obtained by dumping all the light directly in front of the luminaire, using a narrow beam floodlight, for instance. On the other hand, the easiest way to get a uniform light pattern would be to spread the light over a large area without considering how much of it is wasted or lost. These two factors present a challenge to the designer to obtain both high coefficient of utilization and good uniformity of illumination.

In present practice, photometric data for luminaires are supplied in the form of utilization curves, isofootcandle (or isolux) diagrams, lateral candlepower curves in cone of maximum candlepower and candlepower curves in the vertical plane of maximum candlepower. Also, manufacturers have available spherical isocandlepower diagrams.

The isofootcandle diagrams actually provide all the necessary data for application design. Utilization need not be specified as it is computed from the isofootcandle diagrams. However, it serves as a convenient reference to quickly obtain average illumination levels, but provides no information on uniformity. It is recommended that curves showing uniformity be supplied as a companion tool to the utilization curves. Together, these two tools will be useful guides to the application engineer to prevent misleading interpretations of the utilization curves when used alone. Fig. 8 shows a typical uniformity ratio curve.

Maximum permissible variations of minimum illumination from the average are presently specified, and as a key requirement, should be retained.

This leaves the matter of streaks and striations. They may not show up in isofootcandle charts. In fact, the best way to detect and to evaluate them is visually by looking at the light pattern on a street. It is practically impossible to completely eliminate such defects, but it is possible to minimize them to the extent that they become innocuous. Perhaps a paragraph should be inserted in the Recommended Practice to the general effect that: "When viewed on the street the light pattern from the luminaire should be free from objectionable streaks and striations sufficiently pronounced to annoy or confuse the motorist."

If some revisions in this direction were made, it would open the field to all kinds of new ideas and give the design engineer the opportunity for a fuller use of his imagination.

References

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2. Rex, Charles H.: "Luminaire Light Distribution Principles," ILLUMINATING ENGINEERING, Vol. L, No. 12 (December 1955).
3. Higbie, H. H.: "Lighting Calculations," John Wiley & Sons, Inc., 1934.

DISCUSSION

MERLE E. KECK:* This paper fills a definite need for factual information relating to the various methods of analyzing the performance of a street-lighting luminaire by means of photometric curves. The author has raised a number of interesting points and provided considerable factual information, but unfortunately, neither he nor any individual is in a position to resolve the present situation as regards the specification of photometric performance of street-lighting luminaires.

I agree that the candlepower traces now required by the I.E.S. Recommended Practice are of little value and that the classification of luminaires by angular width to the half candlepower point can be very misleading. The method outlined in the paper would appear to be excellent as regards oval type luminaires, where the light source is parallel to the roadway, but would seem to have the same defects as the radial method when applied to luminaires in which the lamps run horizontal to the roadway. When a lamp is placed in an oval luminaire and the lamp is tilted with reference to the pavement, then the image of the arc tube laid down on the street is not perpendicular to the curb, but is at an angle to the curb, and would, of course, intersect a perpendicular plane at only one point along its length. I am sure that the author recognizes this problem, since he, himself, indicates the uselessness of trying to anticipate the form of future street lighting development and the infinite number of classification systems required as new forms are developed.

The uniformity curve of a type shown in Fig. 8 would certainly be of advantage in comparing the anticipated performance of various luminaires, however, it would be necessary to prepare it for staggered spacing, opposite spacing, and one side of the street spacing in order for it to be much use to the application engineer.

In addition, it must be realized that this type of curve applies only on straight roadways and not on curves. For

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this reason, some application engineers now use transparent overlays on scale drawings to determine pole locations.

In general, I agree with Mr. McPhail that our present Standard Practice and the dimensions of roadway classification must be changed. I am not sure that I know the exact form in which they should be made, but I feel that this paper serves a valuable purpose in leading towards that very desirable end.

WILLIAM F. CROSBY:* The author is to be commended for drawing attention to the fact that light distribution from a horizontally mounted linear source is built up of a series of source images, the most useful of which are rectangles approaching lines, and for questioning the applicability of traditional circular coordinate systems in analyzing such a distribution.

The concept of rectangular beam distributions perpendicular to the roadway is limited in practical use. Tilted luminaires, tilted lamps and image reflections originating away from the central axis of the reflector all contribute to skew of the distribution away from the ideal condition of perpendicularity to the roadway.

Under these circumstances it appears that there may not be adequate justification for adding to the complexity of the present Practice a section written in terms of planes, which the author suggests in addition to the present system based on cones.

This does not preclude, however, the possibility of substituting planes rather than cones if further study and thought indicate that this would be desirable.

For the present, under the system of circular coordinates, it is suggested that a rather good picture of the beam as related to the geography of the street is Rex's suggestion in Fig. 16 of his referenced paper of a spherical isocandle diagram with longitudinal and transverse roadway lines superimposed.

The author points out that iso-footcandle diagrams of present practice actually provide all the necessary data for application layouts. This is true so long as horizontal footcandles are the criterion and pavement brightness is not considered. These iso-footcandle diagrams are, of course, related to the geography of the street directly and would not be changed if derived from data taken in the proposed N and E planes.

The suggested uniformity ratio curve is excellent and will save layout time.

The reduction of streaks and striations is certainly most desirable. Possibly, before a paragraph regarding them is inserted into the Recommended Practice, we should be prepared to define them closely enough so that an objective answer can be given to the inevitable question, "How pronounced must they be to be annoying or confusing?"

CHARLES H. REX:** Mr. McPhail's paper is quite refreshing. It reflects his technical skill, his nautical hobby (*i.e.*, "meridians, N & S — E & W," etc.); and his continual desire to properly present the light distribution performance of roadway lighting luminaires.

Mr. Kurt Franck and I agree that the general purpose of Mr. McPhail's paper was to show that analysis of the light distribution from linear light sources (such as clear bulb mercury arc lamps), should be shown in rectangular coordinates.

Rectangular coordinates should be applied generally to roadway lighting luminaires, *i.e.*, those equipped with filament, and fluorescent, as well as mercury lamps. It also applies to the combined performance of several luminaires as they are installed in lighting systems. This is consistent with the rectangular or linear geometry of the roadway, the lanes of vehicular movement, and the driver's line of sight.

There are several filament lamp luminaires in present day use which provide specified rectangular light distribution patterns similar to those described by Mr. McPhail. For many years, such luminaire performance has been specified at the pavement level. Longitudinal and transverse lines of maximum candlepower have been included.

More recently, data have been specified along longitudinal roadway lines several feet above the pavement, representative of the driver's eye-level. I believe Mr. Franck will agree that these eye-level data supply a long felt need for appraisal information pertaining to glare, *i.e.*, both disability veiling brightness and discomfort.

This development of linear and rectangular coordinates more readily shows the control and restriction of glare candlepower which aids night driving conditions.

Now and during the past year, inclined plane candlepower curves and data have been made generally available for several different filament, mercury and fluorescent lamp luminaires. These data show the candlepower distribution from the luminaire extending downward along representative longitudinal roadway lines at both the pavement and eye-level. Thus, luminaire performance and effectiveness may be appraised and compared correctly, in terms of factors pertaining to visibility and comfort. Data constants for conversion of the candlepower data into performance factors such as pavement brightness and disability veiling brightness have also been made available.

It is a long way back to any assumption that iso-footcandle diagrams supply all the information necessary for proper lighting application of luminaires. However, the iso-footcandle curves are plotted on the rectangular coordinates which Mr. McPhail had in mind, usually in multiples of luminaire mounting height. Iso-footcandle diagrams would be easier to use if supplemented by tabulations of the footcandles at uniformly spaced longitudinal and transverse distances. The footcandles may then be readily compared or combined for systems with luminaires spaced in multiples of mh. Data in terms of small uniform squares were recommended in the 1948 Guide by the Committee on Photometric Testing Procedures. Lateral and vertical coordinates, corresponding to uniformly spaced points may be set on the photometer to obtain data readings directly. J. S. Franklin also points out that utilization data need not be computed from the iso-footcandle diagram. They can be, and are more accurately calculated from the iso-candle data.

Reliance on iso-footcandle diagrams at pavement level for effectiveness information, pertaining to factors such as glare, is an unnecessary limitation and a burden on the user.

Mr. Franck probably agrees that data showing the excellence of luminaire design for visibility factors should be available for user appreciation and evaluation as well as iso-footcandle diagrams.

Also, aren't we primarily interested in seeing performance of lighting systems involving several luminaires?

We must somehow dispel the "bugaboo" of photometric data use and interpretation. User application engineers in general devote many hours, days, weeks or even months to

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**General Electric Co., Outdoor Lighting Dep't., Hendersonville, N.C.

analysis of the volts and amperes of the electrical wiring systems. Shouldn't we devote just a little time to the development and analysis of the photometric data which tells us how effective the roadway lighting system will be in producing seeing and visibility? The latter determines how much traffic benefit is derived in terms of user comfort, convenience and safety. Those benefits also determine how much the use of good roadway lighting will be extended this year and next.

Additional questions are as follows:

(1) How recently were all street lighting units round?

(2) Hasn't the rectangular geometry of the street been fitted by using prismatic, shielding and reflector techniques?

(3) Isn't luminaire brightness as well as light distribution properly proportioned by design of each of the large number of elements which Mr. McPhail mentions?

(4) Isn't it true that Fig. 4 graduated rectangles cannot be expected to coincide when the distributions from several luminaires overlay as they do in roadway lighting systems?

(5) Don't we have an opportunity rather than a dilemma?

(6) The present American Standard Practice for Street and Highway Lighting was presented to I.E.S. in September 1952, and adopted by A.S.A. in 1953. Weren't there many installations of mercury lamp luminaires by that time?

Don't the illustrations and wording of this Practice indicate that the sponsoring I.E.S. Committee was mindful of the rectangular street areas involved? For example, in paragraph 2.4 (B) page 11 of the American Standard Practice :"Type I, II, III and IV light distributions should vary in cones at vertical angles other than the maximum cones in order to provide adequate coverage of the rectangular street area involved. . . ."

(7) Doesn't the American Standard Practice Appendix, particularly B7, page 25, show how the width of light distribution (even though measured in cones) varies with the vertical angles to fit specific rectangular roadway widths.

(8) Shouldn't a Recommended Practice or Report be developed to show the advantages of providing light distribution data from a luminaire in the longitudinal and transverse planes of maximum candlepower, and along other representative roadway lines likely to be of interest to the user?

(9) Should it be explained that the rectangular beam does not have the same candlepower at the center, the far side and the near side? Actually, in practice, we experience no difficulty in properly designating the vertical plane or cone of maximum candlepower.

(10) The light distribution for seeing and visibility problem has long prevailed. Which is ahead, the luminaire performance or the user requirement criteria?

(11) Doesn't the incident light direction, relative to driver observer view direction, significantly affect the visibility benefit derived from footcandles?

(12) What is the "confusing of the issue" and research which is questioned? What type of data make a poor light distribution look good, or a good light distribution look bad?

(13) Coefficient of utilization will not be lost or passed up. Isn't "uniformity" much more significant when applied to visibility, pavement brightness or obstacle brightness, etc. — what the user pays for and can see?

(14) Fig. 8 is interesting. However, shouldn't a wider lateral light distribution be used for the 70-foot street width, to keep down to 4:1 ratio per A.S.A. ratios?

Incidentally, I used the term "inclined planes" rather than the "slant planes" which Mr. McPhail attributed to me.

D. A. TOENJES:* The author of this paper is to be commended for presenting his analysis in a way that appears quite understandable to the reader. If not so carefully written, this subject could have been involved and obscure. The illustrations are especially helpful in making his presentation easy to follow.

It appears that in Fig. 1 the assumed light pattern, for a round asymmetric luminaire using a point source, has been exaggerated. If we break this candlepower distribution pattern down into segments, as the author has later done in his analysis, the pattern in Fig. 1 makes it appear that each complete segment is quite large and has a fixed amount of beam spread and light bending given by its prismatic surfaces, resulting in this irregular "saw-tooth" pattern. In actual design, is it not true that individual prismatic effects are specified for much smaller portions of the glassware and of the candlepower pattern from the reflector, to give a smoother light distribution pattern?

In this approach, furthermore, no mention is made of the importance of designing each element of the entire refractor to provide enough brightness in all directions of the main beams so that there will not be extreme brightness differences over the refractor surface as viewed by an observer on the roadway.

Later in the paper, the author suggests that the I.E.S. classifications of luminaire light distribution be modified, and based on geometry of the roadway, rather than angular width of distribution. This will have special merit if it can be shown to be more logical in describing the end-use of the light distribution pattern, and also if it allows these classifications to be more simply defined and computed.

However, he proposes that the classification be in terms of illumination on the roadway. At other points in his paper, he mentions the importance that the illumination cover the roadway area with reasonable uniformity. While we agree with his intention here, we wish to stress that the uniformity, or lack of it, that the motorist or pedestrians see, is actually in pavement brightness, not illumination. As is being brought out by the I.E. Research Intstitute studies on pavement reflection characteristics (Project No. 22) the ratio between pavement brightness and its illumination depends greatly upon the angles of elevation of the light source and the observer's eyes with respect to the pavement surface, as well as upon the pavement surface characteristics themselves. This also affects the statement that the author suggests be included in the American Standard Practice, that the light pattern from the luminaire should be free from objectionable streaks and striations — assuming that he is speaking of the brightness pattern on the roadway, rather than the brightness of the luminaire's refractor itself. To make such a requirement more specific, one would eneed to describe the pavement surface upon which the light pattern was to be evaluated. If it were not practical to do this, as it might not be, then shouldn't the importance of pavement surface characteristics at least be mentioned?

In Fig. 8, the description is incomplete unless luminaire mounting height is shown, or else the dimensions of width and spacing are converted into ratios of width/mh and spacing/mh, respectively. In the figure, we are interested in the fact that for the 70-foot street width the curve is higher at 125-foot spacing than it is at 150-foot spacing. Is this to be expected from over-lapping of luminaires with high-angle cutoff, or does this result from the use of perhaps a

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narrow Type II distribution on a relatively wide roadway, so that there is likely to be a minimum footcandle point at the curb directly opposite the luminaire?

G. G. WHEELER:* I am an application design engineer who designs uniform high level lighting systems for installation in business districts, highways, etc. My discussion, therefore, will be limited to this viewpoint.

Mr. McPhail suggested that a new set of classifications for luminaires be developed based on illumination on the street, however obtained — be it from point sources, horizontal sources, or linear sources. In this I concur, for an applications engineer is really only interested in light on the street provided it is put there with a maximum of ease and comfort to the observer; i.e., as uniform and glareless as possible. It seems to me this should also be the aim of the luminaire designer.

Furthermore, we have already seen test installations of street lighting systems using continuous fluorescent tubes, either down each side of the street or down the center of the street. These may not be the answer, but who can tell what will be next. Hence, if the classifications are to be changed, as appears to be desirable, certainly one based on "illumination on the street, however obtained" would be the most desirable and probably the most permanent.

Mr. McPhail mentioned that, under the generally accepted criteria for illumination of streets, the first requirement of a street light is to light the street; or, in other words, the utilization should be high. For illumination of business streets, I do not agree. The primary purpose here, of course, is to light the street, but a strong secondary purpose is to light the area including the building fronts. In other words, the utilization should not be too high.

I used to believe, as Mr. McPhail apparently did, that street lights were to light the street only, and used to demand higher and higher utilizations until I saw a system in a large city that did an excellent job of confining the light to the street, leaving the building fronts very dark, and the overall effect was very dull. Subsequently, in this city some of the building owners have found it desirable to floodlight their building fronts.

From an equipment manufacturer's standpoint and a utility's load building standpoint, this may be fine, but I have come to believe that the overall purpose of a business district lighting system is to make the area appear bright and well lighted, and this cannot be accomplished by lighting the street only.

This feeling has been strengthened in recent years by the popularity in this area of fluorescent luminaires for business district lighting. We all know the utilization of fluorescent luminaires is low; yet, by popular choice, over the last three years considerably better than 90 per cent of the luminaires installed in business district lighting systems in our company's area have been of the fluorescent type. We doubt that municipal officials and businessmen who choose this type realize it is because they light up the entire area, but they like the effect.

Some who read this may think I favor the old upright type of lighting, but that put most of its light in the air and still did a spotty job of lighting building fronts, let alone the street. So I am all for modern lighting, but let's not go overboard on utilization in business areas.

For other areas, residence streets, highways, etc., good utilization is of primary importance. In residence areas, people do not want light in their windows, and on highways, light off the roadway usually serves no useful purpose.

As to Mr. McPhail's second requirement of a luminaire — uniformity — I agree wholeheartedly. His suggested uniformity ratio curve for every luminaire would be of great help in designing systems.

W. B. ELMER:* In this paper, Mr. McPhail brings out and further develops a valuable point touched on in the Rex reference and also the writer's discussion of Rex's paper to the effect that the standard photometric data for street lights could better be presented on a rectilinear than a polar basis, and in particular, that the present spherical isocandlepower diagram commonly supplied by manufacturers, as recommended in the IES Street Code ought to be revised in such a manner that a straight line lengthwise of the street and parallel to the curb should be representable by a straight line on the iso-candlepower diagram.

In order to accomplish this, it would be necessary to revise the iso-candle diagram so that the parallels are no longer shown as sinusoids. Straight lines to the center of the diagram would then represent straight lines in the street parallel to the curb, giving ready data for candlepower distribution in what Rex calls the "slant planes." It is likely that this change could be made without destroying the equal-area feature of the present diagram so that it would still be possible to integrate the total light output of the luminaire by planimetering the iso-candle lines. This could be a very constructive outgrowth of Mr. McPhail's paper, for which every street lighting engineer would be thankful. We hope this revised diagram will be included in the next American Standard Practice revision.

Referring to the analysis of point source luminaires vs linear source luminaires, it is true that any element of reflected light from a linear source luminaire is linear, as Mr. McPhail says. However, the aggregates of these reflected beams from an oval or round luminaire can still be curved and still produce circles of light and dark patterns on the street surface, as pointed out by the author as a common defect in round luminaires.

Mr. McPhail comments on these common defects in the design of refractors in his first paragraph, and at the bottom of page 196, and again in the next to the last paragraph. This brings up the basic matter of the optical principle of street luminaires. The reflector-refractor principle has many grave defects, which we believe will result in the ultimate adoption of a better principle, known as the diffuser-reflector principle, and which is already incorporated in a commercial street luminaire now being installed on white-ways and highways. In addition to avoiding the striations and streaks so commonly produced by refractors, the new principle permits the economical manufacture of low brightness luminaires in large sizes, using incandescent or mercury lamps which are not practical with refractor types. The new principle also provides extremely uniform brightness of the working luminaire area which has never been achieved with refractor types.

Mr. McPhail also opens up another subject of tremendous importance and one which has been tragically neglected. That is the rhetorical question in the middle of page 196, "What is the ideal distribution of illumination on a street?" Although the vertical distribution shown in the IES Code specifies the maximum candlepower between the limits of 70 to 80 degrees, the sharp cutoff above 80 degrees would

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*Wheeler Reflector Co., Boston, Mass.

give a very poor street light, and in this respect the Code leaves much to be desired. The British Street Lighting Practice recognizes the importance of high angle light between 80 and 90 degrees which eliminates the severe spottiness resulting from an 80-degree cutoff. Another factor which will have to be introduced into the Code in the near future is that of directional lighting for one-way streets and divided highways with which substantially increased visibility per lumen is attained. This principle, which has been contemplated for many years, has only recently been embodied successfully in a commercial luminaire.

In the third from the last paragraph, Mr. McPhail defends the present limitation on maximum permissible variations of minimum illumination from the average. This discusser knows of no engineering basis for the requirement in the Code that the minimum illumination shall not be less than one-fourth of the average illumination on the pavement at any point. It is believed that this requirement is strictly arbitrary and empirical. The ultimate object of street lighting is to obtain visibility and the immediate object is to obtain suitable pavement or obstacle brightness, with a minimum of glare. There is no correspondence between illumination and pavement brightness unless the angular relationships between the source and viewer are held constant. It is easily possible to obtain increased pavement brightness on a given spot of the pavement with a reduction in illumination, if the angular relationships between projected light and viewer are suitably altered. Therefore, it would seem desirable to change this requirement of the Code to substitute the words "pavement brightness" for the word "illumination." This would then allow the street lighting engineer great new latitude in the design and application of street lights.

D. M. FINCH:* Whether or not the luminaire has a short linear source, a filament source or a fluorescent source is of secondary importance in most street lighting calculations since distances are almost always great compared to the dimensions of the source. This means that point-by-point calculations are necessary and the inverse square law is universally applied. The basic data that the design engineer needs is the candlepower distribution data. This is generally available, as the author points out, but it is not used to any great extent by the design engineers.

If the iso-candlepower diagram is furnished in the conventional lateral and vertical angle coordinates, all of the quantities such as North and East angles, flux on various rectangles on the roadway, average illumination, and utilization factors can be readily computed. The author's conversion diagrams and equations are very helpful.

I suggest that the iso-candlepower diagram should be considered as the most important information to be furnished about the luminaire and should be used in classifying the unit.

I agree that the present American Standard Practice for Street and Highway Lighting classifications are not very useful in determining the lighting performance of units. Candlepower distributions in a conical surface and in a vertical plane are not adequate. Neither is the specification of illumination entirely satisfactory. The roadway *brightness* pattern is the real goal. It is well to note the author's concern with this matter in his statement that "there should be no bright and dark areas and no conspicuous streaks or striations." Research is still in progress trying to check the validity of the idea of having uniform pavement brightness. When the requirements for uniformity can be definitely pinned down we will then have a better basis upon which to develop the performance specifications.

May I suggest that the letter *E* be reserved for illumination, and that the east angles have a different symbol?

HAROLD F. WALL:* Mr. McPhail gives a brilliant discussion of the light distribution from horizontal mercury light sources and makes recommendations for changing the American Standard Practice for Street and Highway Lighting. He also makes some very pertinent remarks about the "research project." I heartily endorse his remark that the "best results to date have merely served to confuse the issue."

I assume that Mr. McPhail is trying, in his polite way, to tell us that the lateral light distribution type numbers for mercury vapor fixtures is incorrect as described by Code methods. I took the isolux curves of the new General Electric Type III mercury luminaire and superimposed on it the curve of a General Electric Type IV incandescent luminaire. (See Fig. A.) It seems to me that although the distribution of light from the mercury luminaire approaches a rectangle, it begins to fall off sharply at 60-foot street width and can't compare with the Type IV incandescent unit on streets over this width. Peculiarly enough, interpolation shows that on streets over 60-foot width, the uniformity ratio approaches 4 to 1, the Code limit. Therefore, the distribution type number for mercury vapor fixtures is correct as described by the circular coordinate system in the code.

It is true, however, that light sources will change in size and shape, and that future light distributions will be different so that his Code recommendations should be given a lot of consideration, particularly his recommendation that "Code clarification should be broad enough to cover any satisfactory lighting device or method."

KURT FRANCK:** If Robert McPhail were alive today he would appreciate the generous response to his paper, as shown by the thorough and searching discussions above. The point of his paper, as he expressed himself to his colleagues many times, was to arouse interest in the problem of how best to analyze and specify the light distribution character-

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*Public Lighting Division, Detroit, Mich.
**Holophane Company, Inc., Newark, Ohio, for the author.

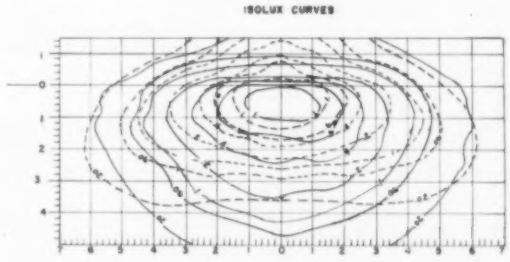
ISOLUX CURVES
LEGEND:
GE F400, H400E1 LAMP (21000 LUMEN) 30FT MOUNTING HEIGHT
GE INCANDESCENT LUMINAIRE (20000 LUMEN LAMP), TYPE IV, 30FT MOUNTING HEIGHT

Figure A.

istics from linear street lighting sources. It would have been gratifying to Mr. McPhail to find that in principle all eight discussers are in agreement with his proposal.

In detail, quite a number of the points which several discussors bring up seem to be well taken. Messrs. Keck and Crosby bring up the difficulty of adapting Mr. McPhail's suggested solution to luminaires in which the linear source is tilted with respect to the horizontal roadway, and such cases undoubtedly call for modification of the McPhail proposal. Messrs. Rex and Toenjes point out that by proper use of reflector and refractor design techniques, the distribution characteristics of Fig. 1 can actually be better fitted to the rectangular geometry of the street than Fig. 1 indicates; this is unquestionably so, McPhail's intention in Fig. 1 having been to show differences in principle in the schematic diagrams of Figs. 1 and 2.

Mr. Rex further states that the choice of the particular rectangular co-ordinate grid shown by McPhail in Fig. 4 does not lend itself well to the analysis of results from several luminaires as they contribute to the illumination at a given point on the roadway in a complete street lighting system. Again, it might be well to modify the details of McPhail's proposal for such practical considerations.

Several of the discussions showed considerable interest in the uniformity chart of Fig. 8. To answer their questions, it might be worthwhile to give in somewhat more detail the development of such uniformity ratio curves.

Fig. 8 was intended merely to show a typical uniformity curve. Certainly, in order to be completely usable there must not only be data on mounting height but indication of overhang and whether staggered, one side, or opposite arrangement is used. All of these will affect the shape of the curves.

The chart in the paper was drawn for a 30-foot mounting height, a staggered arrangement and a 5-foot overhang. This is only one chart of many that have been prepared where the complete set of data, as now prepared, includes average to minimum values, maximum to average values, and also average footcandle curves, to indicate the actual level of horizontal illumination.

To answer specifically the question regarding the shape of the curve, Fig. 8 applies to a Type III distribution that is relatively narrow, with minimum illumination opposite the luminaire on the far side of the street. This is why, for one thing, the 70-foot street curve quickly goes beyond the 4:1 ratio of average to minimum.

It should be noted here that these curves are plotted on the basis of the actual minimum value wherever it may occur on the street, for any condition of spacing and width (with all significant luminaires contributing). In practically every case the location of the minimum value will shift position on the street as the spacing and width increase. The reason for this change in position of minimum value may be due to many different things, each of them alone, or in combination, the direct result of the distribution characteristics of the luminaire. Often this shift takes place more than once, with the location jumping around over the area. This means the rate of change of the minimum value may vary while the rate of change of the average is constant. Since the curves are plotted as a function of the ratio of average to minimum illumination, the curves could, and often do, change direction when the minimum value changes position on the street.

The uniformity curves are another way of looking at the candlepower distribution from the standpoint of the final overall results in horizontal footcandles from a system of luminaires. If there were always a straight line relationship between average and minimum footcandles, there would be little need for curves of this type. There will seldom, if ever, be a straight line relationship and the real worth of these curves, therefore, is that they quickly and readily point out the performance characteristics of any distribution and accurately establish the limits of application of that distribution.

Deadline for Ballots—May 26

Exercise your privilege to vote in the election of National and Local I.E.S. Officers and on other Society changes, including some revisions in the I.E.S. Constitution. Ballots were mailed to members on April 5 and, to be counted, must reach the General Secretary not later than May 26, 1958.

INSTALLATION AT ST. LUKE'S CHURCH,
SYCAMORE ST. AND MILLER AVE., BUFFALO, N. Y.

Lighting a Church

LIGHTING OBJECTIVE: To enhance the beauty of this newly decorated, spacious basilican interior through lighting from concealed sources and provide general illumination for occasional reading.

GENERAL INFORMATION: The nave, shown above, is approximately 128 feet by 46 feet with a 45-foot ceiling height. The ceiling and the walls are ivory (70% RF) with deep blue and gold decorations and with murals in a variety of colors. The altar is marble (center panel 80% RF, background 40% RF) and golden bronze. The half dome of the sanctuary is deep blue (5% RF), powdered with gold stars. The reflectance of the reredos, pews and floor are 30%, 10%, and 20%, respectively.

(over)

A.I.A. File No. 31

INSTALLATION: Illumination in the nave is provided by: Twelve Rambusch luminaires, Catalog No. BIA-24-V (equipped with 1000-watt bi-post lamps) spaced 21 feet apart in two rows 21 feet on centers; and forty-eight 150-watt PAR-38 flood lamps (on approximately 5½-foot centers and aimed 35 degrees up towards the ceiling) concealed in the two wall cornices located 20 feet below the ceiling. The altar is illuminated by six 150-watt PAR-38 flood lamps in shielded enclosures concealed behind the sanctuary arch and piers. The mural on the half dome is lighted by an additional two 150-watt PAR-38 lamps concealed in the cornice above the reredos.

Twelve months after installation, illumination readings were: nave — 12 footcandles, including 3 footcandles with the indirect lighting alone; altar — 15 footcandles (vertical). Brightnesses were as follows:

Luminaires at 45°	200 fL	Sanctuary dome — figure	3 fL
Ceiling	8 fL	Reredos	2 fL
Upper wall	4 fL	Pews	1 fL
Wall above cornice	6 fL	Floor	2 fL
Altar	10 fL		

Lighting designed by Niagara Mohawk Power Corp. and lighting installed by Robertson Electric Co., Inc., both of Buffalo, N. Y.

Lighting data submitted by Niagara Mohawk Power Corp., Buffalo, N. Y., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Photometer for Measurement of Effective Intensity of Condenser-Discharge Lights

By CHARLES A. DOUGLAS

1. Introduction

In the past, measurements of the effective intensity of condenser-discharge lights have generally been made by two methods: (1) coupling the output of a phototube to a cathode-ray oscilloscope, photographing the trace of the instantaneous intensity against time, integrating the area under the curve and computing the effective intensity; and (2) charging a capacitor by the photoelectric current generated by one or more flashes and measuring the voltage developed with a vacuum-tube voltmeter. Both of these methods are time consuming when intensity distribution measurements of a projector with a flashing source are being made. In addition, when the source is a condenser-discharge lamp, there has often been uncertainty about the accuracy of the correction of the spectral response of the photometric system to the CIE standard observer luminosity function; the sensitivity may be so low that short photometric distances are required; although the average photoelectric current is low, peak currents are high, and, unless suitable precautions are taken, the phototube may be saturated during part of the flash, destroying the linearity of the system. A method that will allow measurements of the effective intensity distribution of condenser-discharge units producing repetitive flashes to be made and recorded automatically is very desirable. The development of such a method, designed to avoid difficulties of the types described above and making use of commercially available equipment, wherever possible, is described below.

2. Effective Intensity Photometer

The effective-intensity photometric system is shown schematically in Fig. 1. The test and standard distances, the intensity of the standard lamp, and the transmittance of the sector disc are chosen so that the average illumination on the photocell during calibration is of the same order as the illumination from the projectors under test. The sector disc was used to obtain flashes during calibration which had roughly the same intensity-time relation as the flashes from the lights under test. (As will be shown below, this latter condition is not necessary.) With this system it is possible to obtain in approximately three minutes an intensity distribution curve of a projector using a condenser-discharge lamp which produces repetitive flashes.

Light from either the test unit or the standard lamp falls on a diffusing glass so that the distribution of illumination on the photosensitive surface of the phototube is independent of the distance of the light source. A small aperture in front of this glass is used to control the illumination on the phototube. The light then passes through the luminosity filter to the phototube. This filter is so designed* that the spectral response of the phototube-filter-diffusing glass combination is essentially that of the luminosity function of the CIE standard observer.[1]

A type PJ-14B phototube is used because it is stable, it has a low dark current, and its relatively flat spectral response simplifies the design of the luminosity filter. The correction for the spectral sensitivity of the phototube by the luminosity filter is sufficiently accurate for the photometry of any non-chromatic ("white") light using an incandescent lamp or a conventional flashtube. The luminous sensitivity of the phototube-filter combination is sufficiently high so that the photometric distance may be made as large as necessary.

The output current of the phototube is smoothed by the resistance-capacitance network so that the phototube will not be saturated and the d-c electrometer-amplifier will not be overloaded during the flashes and so that output current will be sufficiently stable to produce a smooth curve on the recording potentiometer. The output of the system is, of course, proportional to the average photoelectric current and hence to the average illumination at the phototube.

The General Radio Type 1230A d-c amplifier and electrometer is operated with its "Ground" switch

This paper was prepared as a part of the work in the development of aviation ground lighting conducted at the National Bureau of Standards under the sponsorship of the Visual Landing Aids Branch of the Bureau of Aeronautics and the Aeronautical Accessories Laboratory, Wright Air Development Center. AUTHOR: National Bureau of Standards, Washington, D. C.

*The luminosity filter was designed by Mr. I. Nimeroff of the National Bureau of Standards.

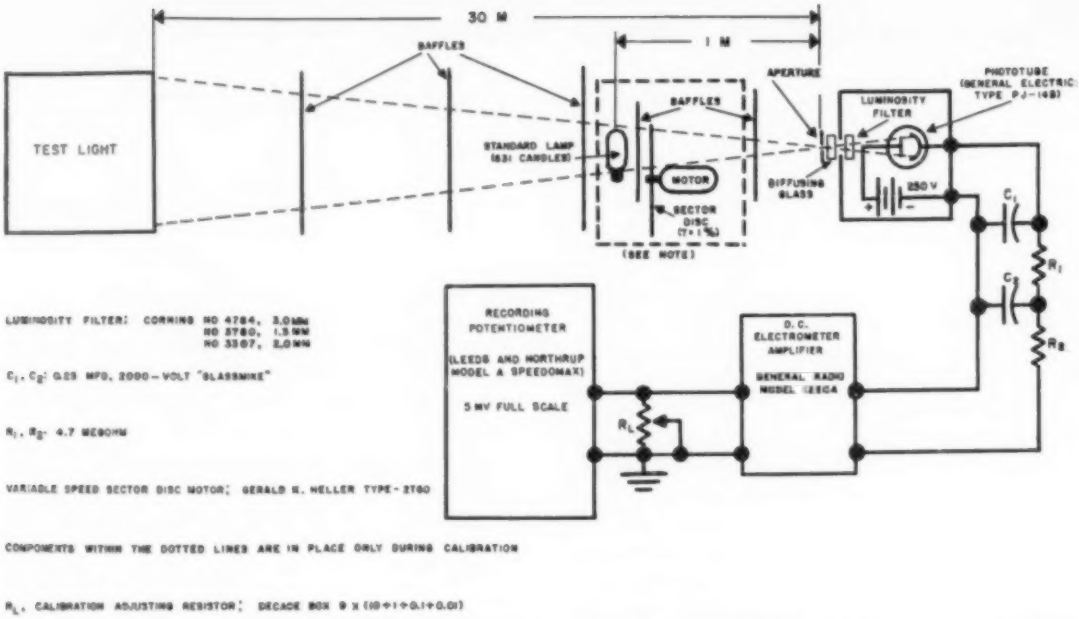

Figure 1. Block diagram of effective-intensity photometric system. Components with dotted lines are in place only during calibration. R_L, calibration-adjusting resistor, is a decade box adjustable by 0.01-ohm steps to 99.99 ohms.

in the "I" position. With this arrangement, use of a single capacitor across the input of the instrument is unsatisfactory because the feedback in the instrument produces low-frequency oscillations (of the order of 0.1 to 0.5 cps) in the output. A network of the type shown eliminates these oscillations. With the "Ground" switch in the "E" position, a single capacitor across the input may be used. The time constant of the circuit is then a function of the capacitance across the input and the input resistance selected by means of the "Input Resistance" switch of the electrometer-amplifier. The arrangement shown is considered preferable unless very long time constants are required, for the time constant is relatively independent of the input resistance selected and may be readily adjusted by changing the values of R_1 and R_2. Ordinary carbon resistors are satisfactory, but capacitors with very high leakage-resistance are required to obtain stability of calibration.

The electrometer-amplifier is designed to operate an external five-milliampere full-scale meter or recorder. However, the recording potentiometer available had a five-millivolt full-scale range. Load resistor R_L is used to obtain a suitable input signal for the recording potentiometer from the output current of the electrometer-amplifier. It also provides a convenient means of making small adjustments of the over-all sensitivity of the photometric system. The minimum value used for R_L is one ohm in order that a full-scale reading of the potentiometer may be obtained before the electrometer is overloaded.

3. Theory of Operation

The method of obtaining the effective intensity of a condenser-discharge light flashed at a known rate from measurements of the average intensity is developed below.

3.1 *Definitions of Terms and Symbols.*

The terms and symbols used in this paper are defined as follows:

- I the instantaneous intensity of the test light during a cycle
- $\bar{I}$ the average intensity of the test light during a complete flash cycle
- I_e the effective intensity of the test light
- I_s the intensity of the standard lamp
- T the transmittance of the sector disc
- D the distance between the test light and the diffusing glass of the photometer
- d the distance between the standard lamp and the diffusing glass of the photometer
- τ the time in seconds required for a complete flash cycle

R the recorder reading for the test source
R_s the recorder reading during calibration with the standard lamp and rotating sector disc.

3.2 *Basic Relations.*

The effective intensity is defined as

$$I_e = \frac{\int_{t_1}^{t_2} I\,dt}{0.2 + t_2 - t_1}, \tag{1}$$

where t_1 is the time in seconds of the beginning of the flash and t_2 is the time of the end of the flash. An equation of this form was first suggested by Blondel and Rey but has rarely been used.[2]

The times t_1 and t_2 are chosen so that I_e is equal to I at these times.[3] However, if the effective intensity is sufficiently small in comparison to the instantaneous intensity over most of the flash then $\int_{t_1}^{t_2} I\,dt$ may be replaced by $\int_0^{\tau} I\,dt$ without introducing significant errors. In addition, the flash of a condenser-discharge light is so short (generally less than 0.001 second) that $t_2 - t_1$ is negligibly small in comparison to 0.2.

Therefore equation (1) may be rewritten as

$$I_e = 5 \int_0^{\tau} I\,dt. \tag{2}$$

But

$$\bar{I} = \frac{\int_0^{\tau} I\,dt}{\tau}. \tag{3}$$

Therefore

$$I_e = 5\bar{I}\tau. \tag{4}$$

Note that τ, the period of the flash cycle, must be known, and must be stable, to the same degree of accuracy as is desired for the effective intensity.

The time constant of the input circuit is sufficiently long so that the recorder indication is nearly steady and proportional to the average current of the phototube. During a flash the photoelectric current charges capacitor C_1 and the voltage across the phototube is not decreased appreciably. Hence the phototube does not saturate and the photoelectric current is at all times proportional to the illumination on the phototube.

Therefore, the recorder reading is given by

$$R = \frac{k\bar{I}}{D^2}, \tag{5}$$

where k is a constant of proportionality which is a function of the exposed area of the diffusing glass, the input resistance of the d-c amplifier, the range on which the amplifier is set, the load resistance across the output of the amplifier, and the sensitivity of the recorder.

Combining equations (4) and (5),

$$\frac{I_e}{R} = \frac{5\tau D^2}{k}. \tag{6}$$

For ease in interpretation of the recorder charts, the ratio I_e/R is made the product of either an integer, or the reciprocal of an integer, and an appropriate power of ten by adjusting the parameters of the circuit to obtain the proper value of k. The recorder chart can then be graduated in a convenient number of effective candles per chart division.

3.3 *Calibration.*

The calibration of the photometric system to obtain the proper value of k is accomplished by means of a standard lamp.

Since

$$R_s = \frac{k I_s T}{d^2}, \tag{7}$$

then

$$R_s = 5\tau D^2 \frac{R}{I_e} \cdot \frac{I_s T}{d^2}. \tag{8}$$

A value of I_e/R is chosen and the parameters of the photometric system are adjusted to obtain the desired R_s. The aperture of the photometer is kept sufficiently small so that the phototube will not be saturated during a flash. The electrometer-amplifier is generally operated on the 100- or 300-millivolt range using an input resistance of 10^7 or 10^8 ohms. The maximum output of the instrument is kept near, but below, the design maximum. Final adjustment of the calibration is obtained by adjusting the value of the Resistor, R_L, across the amplifier output until the voltage drop across this resistor drives the recorder to the desired reading, R_s.

3.4 *Performance Tests.*

The photometric system was calibrated by means of a standard lamp one meter from the photometer and two 2-aperture sector discs having transmittances of 0.0098 and 0.0252. These sector discs were used as designed and also with one aperture blocked, resulting in transmittances of 0.0049 and 0.0126. The discs were driven at speeds of 80 rpm and greater. Under these conditions the variation of the illumination on the photometer during the time of exposure approximates that obtained with condenser-discharge lamps. No measurable change of response with variation in speed of rotation of the sector discs from 30 to 1000 rpm was found. The recorder readings were proportional to the four transmittances of the sector discs within the accuracy with which the recorder chart could be read.

Measurements have been made automatically of

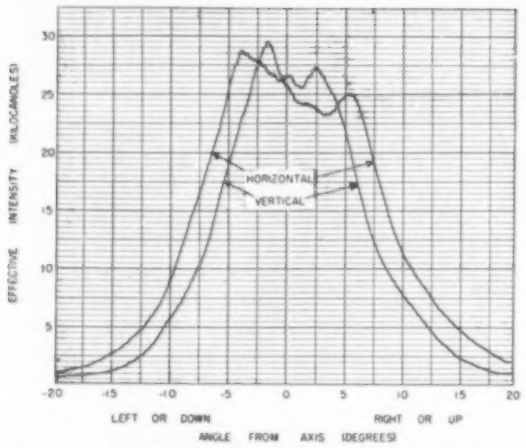

Figure 2. Typical horizontal and vertical intensity distributions made automatically with the effective-intensity photometer of a projector with a flash rate of two per second.

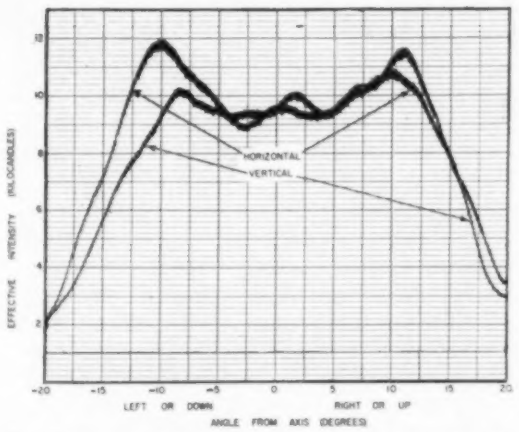

Figure 3. Typical horizontal and vertical intensity distributions made automatically with the effective-intensity photometer of a projector with a flash rate of one per second.

the intensity distributions of a number of projectors which use condenser-discharge lamps. The light under test was mounted on a goniometer to permit rotation about a fixed horizontal axis perpendicular to the photometric axis and about a secondary axis perpendicular to the first and initially vertical. These angles are referred to as "vertical" and "horizontal" respectively. Traverses were taken by driving the goniometer and the recorder-chart drives with synchronous motors, thus recording the intensity of the light as a function of the angle from the axis of the light. The speed of the goniometer drive was 7.5 degrees per minute. This speed was sufficiently slow so that the photometric system could follow the changes in intensity even with the long time constant introduced by the smoothing network in the input circuit to the d-c amplifier.

Examples of these measurements are shown in Figs. 2 and 3. As shown in Fig. 2, when the flash rate is two per second, the time constant of the photometric system is sufficient to smooth the curves so that the effect of the individual flashes is not shown. However, as shown by Fig. 3, when the flash rate is one per second, the effect of the individual flashes is visible. This effect could have easily been reduced by lengthening the time constant of the system by increasing the value of R_1 and R_2. However, the time constant would then have been so long that the scan rate of the goniometer would have had to be considerably slower than the 7.5 degrees per minute rate used when these figures were recorded.

4. Discussion

The photometer system described here is, of course, not limited to the photometry of condenser-discharge lights only, but is applicable to any light having a flash duration of less than about one millisecond (between the times when the intensity is about 5 per cent of peak intensity). The effective intensity distributions of lights with flash durations somewhat longer than one millisecond (up to about 0.01 second) can often be recorded automatically with this system if a suitable correction factor is included in the calibration. This factor is the ratio of the effective intensity computed by equation (1) to that computed by equation (2).

The components used in the system described here can, of course, be replaced with components having similar characteristics. Those listed in Fig. 1 were used because they were readily available.

References

1. *IES Lighting Handbook*, Second Edition (1952) Section 1.
2. Blondel, A. and Rey, J.: *Journal de Physique*, 1 (5th Series), 643 (1911).
3. Douglas, C. A.: "Computation of the Effective Intensity of Flashing Lights," ILLUMINATING ENGINEERING, Vol. LII, No. 12 (December 1957).

INSTALLATIONS IN RESIDENCE OF STANLEY PATTERSON, DALLAS, TEXAS.

Transilluminated Curtains

LIGHTING OBJECTIVE: To conceal several small and unattractive windows and provide a large area, low brightness source of general lighting.

GENERAL INFORMATION: In redecorating this older house, the entire window wall of the dining room shown above was covered with full (fabric four times wall width) pleated curtains made of finely woven white nylon (80 per cent reflectance). This room faces west and receives the uncomfortably strong Texas sun all afternoon so the cream colored window shades are kept drawn; the sunlight is diffused through the shades before it reaches the curtain. (This side of the house is only 15 feet from an adjacent one, so there is no view.) The entire house is air conditioned so the windows are rarely opened. There are venetian blinds over the windows behind the curtains in the bedroom shown on the next page.

Room colors and approximate reflectances are as follows:

	Dining Room		Bedroom	
Ceiling	Cream	70% RF	Pale Aqua	70% RF
Window Shade or Blind	Cream	70% RF	White	80% RF
Walls	Cream	70% RF	Pale Aqua	70% RF
Carpets	Beige	50% RF	Aqua	40% RF
Wood Furniture	Walnut	15% RF	Walnut	15% RF
Drapery			Aqua	40% RF

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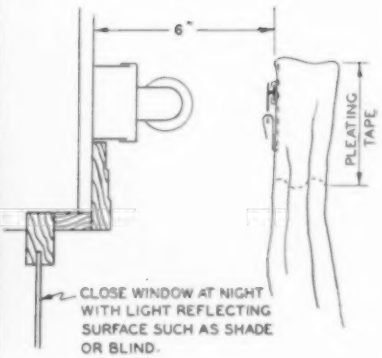
Transilluminated Curtains (Continued)



INSTALLATION: Wiring channels, with 40-watt rapid start fluorescent lamps, are mounted continuously (socket back to socket back) six inches behind the curtain headings. Three deluxe warm white lamps are used in the dining room, and two deluxe cool white (to emphasize the aqua colors) on the bedroom wall area behind the bed.

The decorative dining room luminaire is a Lightolier No. 4214 with four 25-watt lamps. In the bedroom, the center ceiling luminaire is a Puritan No. 1522 with four 40-watt lamps, and the recessed luminaire over the desk is a Lightolier No. 7991/7997 with a 150-watt lamp. (The window behind the desk does not have the fluorescent lighting treatment.)

Lighting results are as follows:

Illumination	
Dining Table	
Curtain lighting only	15 fc
Decorative luminaire only	3 fc
Desk Top (Bedroom)	40 fc

Brightnesses (Dining Room)	
Ceiling above lighting	59 fL
Wall above lighting	36 fL
Curtain	
Just below heading	160 fL max.
	62 fL (at normal viewing angle)
1 foot below heading	57 fL
3 feet below heading	12 fL
5 feet below heading	4.4 fL
Wall opposite curtain	5.7 fL

Lighting designed by Ruth Patterson, Dallas Power and Light Co., Dallas, Texas.

Lighting data submitted by Ruth Patterson as one solution to a lighting problem and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Lamps for Aircraft Lighting

I.E.S. Recommended Practice, prepared by the Subcommittee on Aviation Lamps (Miniature) of the Aviation Committee of the Illuminating Engineering Society

FOREWORD

The lamp table in this Recommended Practice has been prepared as a revision of the table titled "Lamps For Aircraft Lighting, IES-SAE Recommended Practice," which was published in the April 1950 issue of ILLUMINATING ENGINEERING.

This table lists the lamps by application and includes trade numbers, Air Force-Navy or Military Standard Numbers and essential design data for equipment designers.

It should be emphasized that this table does not include all of the lamps now available or now used in aircraft lighting. In omitting some of the lamps now employed, the Committee has no intention to restrict the design of new equipment. Its objective is to guide design toward the use of the best lamp for each service.

The Subcommittee is still active and plans to make revisions from time to

Approved by the Council of the Illuminating Engineering Society, September 1957. A Transaction of the Society.

Lamps for Aircraft Lighting — IES Recommended Practice

(The lamps shown are those recommended for the service indicated. This list is not intended to be a catalog and hence does not include many types of lamps now in use.)

Service	Design Volts	Trade No.	Air Force-Navy or Military Standard No.	Amperes, Watts, or Candlepower	Bulb	Base	Filament	Light Center Length (Inches)	Max. Overall Length (Inches)	Amps[a] at Design Volts	Rated Avg. Lab. Life[b] (Hours)	Approx. Weight (Pounds)
1. Landing	13.0	4537[c]	—	100-W	PAR-46	Scr. Term.	C-6	—	3 1/8	7.69	25	0.92
2. Landing	13.0	4522[c]	—	250-W	PAR-46	Scr. Term.	C-2	—	3 1/8	19.23	25	0.92
3. Landing	28.0	4523[c]	AN3129-4523	250-W	PAR-46	Scr. Term.	C-13	—	3 1/8	8.92	25	0.92
4. Landing	28.0	4556[c,d]	—	1000-W	PAR-64	Scr. Term.	CC-8	—	3 3/8	35.70	25	2.00
5. Landing	28.0	4559[c]	AN3120-4559	600-W	PAR-64	Scr. Term.	CC-8	—	3 3/8	21.41	25	2.00
6. Landing	28.0	4581[c,d]	—	450-W	PAR-46	Scr. Term.	CC-8	—	3 1/8	16.08	10	0.92
7. Landing	28.0	4596[c,d]	—	250-W	PAR-36	Scr. Term.	CC-8	—	2 3/8	8.93	25	0.52
8. Landing	115.0	4569[c]	—	600-W	PAR-64	Scr. Term.	CC-13	—	3 3/8	5.22	25	2.00
9. Taxiing	28.0	4550[c]	—	250-W	PAR-56	Scr. Term.	CC-6	—	4 1/2	8.92	25	1.45
10. Taxiing	28.0	4551[c]	—	250-W	PAR-46	Scr. Term.	CC-6	—	3 1/8	8.92	25	0.92
11. Taxiing	28.0	4570[c]	—	150-W	PAR-46	Scr. Term.	CC-6	—	3 1/8	5.36	300	0.92
12. Taxiing	28.0	4587[c,d]	—	250-W	PAR-36	Scr. Term.	CC-8	—	2 3/8	8.92	25	0.52
13. Position	12.8	93	—	15-CP	S-8	S.C. Bay.	C-2R	1 1/8	2	1.04	500	0.021
14. Position	12.8	1777	—	24-CP	S-8	S.C. Bay.	C-2R	1 1/8	2	1.5	300	0.021
15. Position	13.0	7512-12[e,f]	—	26-W	GG-10	S.C. Ind.	C-2R	—	2 3/16	2.0	300	0.019
16. Position	13.0	4174-12[e,f]	—	40-W	GG-12	S.C. Ind.	C-6	—	2 1/2	3.08	300	—
17. Position	28.0	7512[e,ff]	—	26-W	GG-10	S.C. Ind.	CC-6	—	2 3/16	.93	300	0.019
18. Position	28.0	4174[e,ff]	—	40-W	GG-12	S.C. Ind.	CC-6	—	2 1/2	1.43	300	—
19. Position	28.0	1683	MS-35478-10	32-CP	S-8	S.C. Bay.	2C-2R	1 1/4	2	1.02	500	0.021
20. Position	28.0	311	AN3133-311	50-CP	S-11	S.C. Bay.	C-2V	1 1/4	2 3/8	1.28	300	0.022
21. Position	28.0	4505R[e,g]	AN3144-R4505	50-W	PAR-36	Scr. Term.	CC-6	—	2 3/4	1.78	400	0.52
22. Anti-Collision	13.0	7079-12[e,f]	—	40-W	GG-12	S.C. Ind.	C-6	—	2 1/2	3.08	150	—
23. Anti-Collision	28.0	7079[e,ff]	—	40-W	GG-12	S.C. Ind.	CC-6	—	2 1/2	1.43	150	—
24. Anti-Collision	28.0	4594[e]	—	100-W	PAR-36	Scr. Term.	CC-6	—	2 3/4	3.57	300	0.52
25. Wing Inspection	28.0	4502[c]	AN3144-4502	50-W	PAR-36	Scr. Term.	CC-6	—	2 3/4	1.78	400	0.52
26. Interior	13.0	77	AN3141-77	3-CP	G-5	S.C. Bay.	C-2V	11/16	1 3/8	.37	1000	0.012
27. Interior	13.0	89	MS-15570-5	6-CP	G-6	S.C. Bay.	C-2R	5/8	1 7/16	.71	Indef. Long	0.012
28. Interior	13.0	1383[e]	MS-35480-1	20-W	R-12	S.C. Bay.	C-8	—	2 5/8	1.54	300	0.026
29. Interior	12.8	1141	MS-35478-4	21-CP	S-8	S.C. Bay.	C-2R	1 1/4	2	1.34	500	0.021
30. Interior	28.0	301	AN3141-301	3-CP	G-5	S.C. Bay.	C-2F	11/16	1 3/8	.17	500	0.012
31. Interior	28.0	303	MS-15570-6	6-CP	G-6	S.C. Bay.	C-2F	5/8	1 7/16	.30	500	0.012
32. Interior	28.0	307	MS-35478-6	21-CP	S-8	S.C. Bay.	C-2V	1 1/8	2	.65	300	0.021
33. Interior	28.0	307IF[h]	—	21-CP	S-8IF	S.C. Bay.	C-2V	1 1/8	2	.65	300	0.021
34. Interior	28.0	307SB[i]	MS-35478-7	.65-A	S-8	S.C. Bay.	C-2V	1 1/8	2	.65	300	0.021
35. Interior	28.0	311	AN3133-311	50-CP	S-11	S.C. Bay.	C-2V	1 1/4	2 3/8	1.28	300	0.022

Footnotes a-j at end of table on the following page.

Lamps for Aircraft Lighting — IES Recommended Practice *(continued)*

	Service	Design Volts	Trade No.	Air Force-Navy or Military Standard No.	Amperes, Watts, or Candlepower	Bulb	Base	Filament	Light Center Length (Inches)	Max. Overall Length (Inches)	Amps[a] at Design Volts	Rated Avg. Lab. Life[b] (Hours)	Approx. Weight (Pounds)
36.	Interior	28.0	311SB[d]	AN3133-SB311	1.28-A	S-11	S.C. Bay.	C-2V	$1\frac{1}{4}$	$2\frac{5}{8}$	1.28	300	0.022
37.	Interior	28.0	1385[e]	MS-35480-2	20-W	R-12	S.C. Bay.	CC-8	—	$2\frac{5}{8}$	.71	300	0.026
38.	Interior	28.0	8115-24[e f]	—	20-W	GG-12	S.C. Ind.	CC-6	—	$2\frac{1}{2}$	.71	300	—
39.	Interior	[j]	—	—	6-W	T-5	Min. Bipin	—	—	9	—	—	—
40.	Interior	[j]	—	—	8-W	T-5	Min. Bipin	—	—	12	—	—	—
41.	Interior	[j]	—	—	14-W	T-12	Med. Bipin	—	—	15	—	—	—
42.	Interior	[j]	—	—	15-W	T-8	Med. Bipin	—	—	18	—	—	—
43.	Interior	[j]	—	—	20-W	T-12	Med. Bipin	—	—	24	—	—	—
44.	Interior	[j]	—	—	30-W	T-8	Med. Bipin	—	—	36	—	—	—
45.	Indicator	6.0	328	MS-15544-1	.2-A	T-$1\frac{3}{4}$	Mid. Flange	C-6	$\frac{3}{8}$	$\frac{5}{8}$	.2	500	0.0012
46.		13.0	77	3141-77	3-CP	G-5	S.C. Bay.	C-2V	$\frac{11}{16}$	$1\frac{3}{8}$	.37	1000	0.012
47.		13.0	89	MS-15570-5	6-CP	G-6	S.C. Bay.	C-2R	$\frac{3}{4}$	$1\frac{7}{16}$	.71	Indef. Long	0.012
48.		13.0	1816	AN3121-1816	.33-A	T-$3\frac{1}{4}$	Min. Bay.	C-2V	$\frac{5}{8}$	$1\frac{3}{16}$	.33	1000	0.006
49.	or	14.0	330	—	.08-A	T-$1\frac{3}{4}$	Mid. Flange	C-2F	$\frac{5}{8}$	$\frac{5}{8}$	.08	750	0.0012
50.		28.0	301	AN3141-301	3-CP	G-5	S.C. Bay.	C-2F	$\frac{11}{16}$	$1\frac{3}{8}$	.17	500	0.012
51.		28.0	303	MS-15570-6	6-CP	G-6	S.C. Bay.	C-2F	$\frac{3}{4}$	$1\frac{7}{16}$	.30	500	0.012
52.		28.0	313	MS-15571-4	.17-A	T-$3\frac{1}{4}$	Min. Bay.	C-2F	$\frac{5}{8}$	$1\frac{3}{16}$	.17	500	0.006
53.		28.0	327	AN3140-327	.04-A	T-$3\frac{1}{4}$	Mid. Flange	C-2F or C-21	$\frac{5}{8}$	$\frac{5}{8}$	.04	1000	0.0012
54.	Instrument	28.0	1493	MS-25069-1493	6-CP	T-$4\frac{1}{2}$	Min. Bay.	C-2F	$\frac{5}{8}$	$1\frac{3}{8}$	.30	500	—
55.	Signalling	26.0	4501[e]	AN3126-4501	5.3-A	PAR-36	Scr. Term.	4CC-8	—	$2\frac{5}{8}$	5.3	50	0.52

[a] For purposes of wiring design, maximum amperes at design volts may be approximately 15 per cent greater than design amperes.
[b] Under specified test conditions.
[c] Beam data for PAR lamps:

Lamp No.	Type Cover Glass	Approx. Initial Max. Candlepower	Approx. Spread to 10 Per Cent Maximum (Degrees) Horizontal	Vertical
4501	Clear	60,000	11	12
4502	Lens	19,000	40	7
4505R	Clear	5,000 (Red)	11	6
4522	Clear	290,000	12	10
4523	Clear	225,000	15	11
4537	Clear	200,000	11	6
4550	Lens	75,000	33	8
4551	Lens	75,000	50	10
4556	Clear	800,000	12	13
4559	Clear	570,000	11	12
4569	Clear	400,000	18	10
4570	Lens	32,000	50	9
4581	Clear	400,000	13	14
4587	Lens	40,000	40	13
4594	Clear	65,000	13	7
4596	Clear	150,000	11	12

[d] Consult lamp manufacturer before using.
[e] Reflectorized bulb.
[f] Not trade number. Available from Grimes Manufacturing Company.
[ff] Available from Grimes Manufacturing Company.
[g] Passing lamp, red cover.
[h] Inside frosted.
[i] Silvered bowl.
[j] Fluorescent lamp to be used with auxiliary of proper design; does not operate satisfactorily over the temperature range required for military aircraft.

time, such as this one, in keeping with new knowledge and advanced practices.

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I.E.S. Guide for

Measuring and Reporting Daylight Illumination

Prepared by the Subcommittee on Measurement and Reporting on Daylighting of Interiors of the Daylighting Committee of the Illuminating Engineering Society

Foreword

At the 1954 Daylighting Committee meeting, a Subcommittee on Measurement and Reporting on Daylighting of Interiors was established to study the need of a guide for measurement and reporting of daylighting. Under the chairmanship of Dr. E. E. Vezey, the Subcommittee undertook a survey of literature on the subject of daylight survey techniques, both in the United States and Europe. This survey was completed in 1955, and as a result, the Subcommittee reported that possibly two guides for measurement and reporting of daylighting should be undertaken. The Committee recommended a simplified technique for making daylighting surveys with a minimum of equipment necessary and a comprehensive technique requiring laboratory-type equipment.

It was found that the daylighting techniques being used since 1950 were a composite of the various ideas previously used, and would consequently be a basis for a daylighting survey technique. The principle difference in the new techniques was that of dividing the incident illumination into the three basic components — the sun, the illumination from above the horizon excluding the sun, and the illumination from below the horizon. It was further found that the photographic recording technique lent itself well to daylighting surveys.

In 1956, the Committee undertook the problem of developing the comprehensive lighting survey technique under the Chairmanship of J. W. Griffith. This proposed guide is the result of this undertaking. In attempting to devise a simplified technique for measurements and reporting of daylighting, the Subcommittee found that very little simplification could be obtained and still retain the necessary data to permit comparison between daylighting surveys.

Approved by the Council of the Illuminating Engineering Society, June 1957. A Transaction of I.E.S.

SUBCOMMITTEE ON MEASUREMENT AND REPORTING ON DAYLIGHTING OF INTERIORS

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1. General

1.1—*Objective*—To provide a guide for measuring and reporting illumination within buildings from daylight alone to permit systematic evaluation of daylighting design.

1.2—*Quantities Measured*

1.2.1—*Exterior Quantities Measured*—Since the interior illumination is dependent both on quantity of incident illumination and direction of incident illumination, it is necessary to take the following exterior readings for each fenestration area:

(1) The total incident illumination measured in the plane of the fenestration area or in a parallel plane at the outer edge of any exterior control device.

(2) The incident illumination from the sun only (measured in the same plane as (1) above), and record its altitude and azimuth.

(3) The incident illumination from above the horizontal excluding sun (measured in the same plane as (1) above).

(4) The incident illumination from below the horizontal (measured in the same plane as (1) above).

(5) The total incident illumination measured in a horizontal plane in an unobstructed position.

(6) Brightness measurements of the sky vault visible from the fenestration.

(7) Average brightness of large area surfaces visible from the fenestration such as the ground, concrete areas, or buildings.

1.2.2—*Interior Quantities Measured*

(1) The illumination incident on a 30-inch work plane at points 5 feet in from each wall, at mid points along the walls 5 feet in and at the center of the room.

(2) Illumination values or brightness readings on the walls and ceilings at the location shown in Fig. 1.

(3) Average reflectances of all sur-

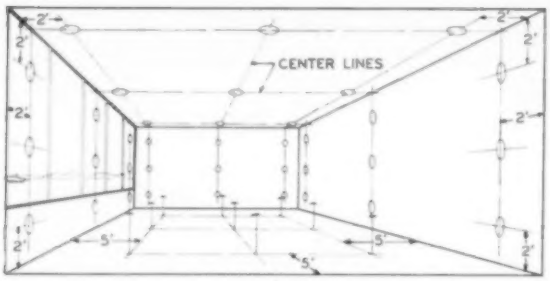

Figure 1. Sketch showing locations for illumination values or brightness readings.

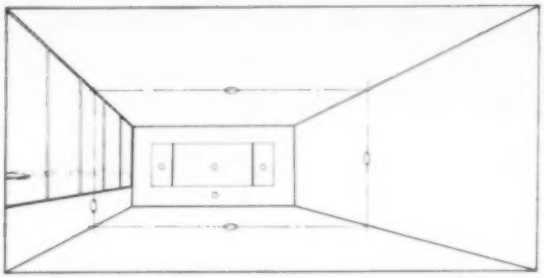

Figure 2. Sketch showing locations for measuring and recording reflectances.

faces within the room containing sixteen square feet or more and with different reflectances.

1.3—*Conditions of Tests*

(1) For best results, tests should be run under stable daylight conditions.

(2) Tests run on partly overcast days should be taken with instantaneous recording devices.

(3) All electric lighting should be turned off during tests.

(4) Adjustment of all control should be noted.

1.4—*Test Equipment and Procedure*

(1) Brightness meter — Either a visual comparison, photoelectric, or equivalent brightness meter should be employed.

(2) Illumination values may be obtained by the use of brightness meters and a test plate of known reflectance or with cosine-corrected and color-corrected photocells. In using filters on photocells, the filters should be neutral density and placed under the cosine corrector in such a manner that the cosine characteristic will not be altered.

(3) Calibrations — All meters should be in calibration as used and a note made of when calibration was run. If filters are employed, the instrument should be calibrated with the filter in place.

(4) For non-stable tests instantaneous recording techniques such as photographic recorders should be employed.

(5) All exterior illumination readings should be taken before and after the interior tests for stable exterior conditions and constantly throughout the entire tests for non-stable conditions. Sky brightness readings should be taken before and after the interior test.

(6) Exterior illumination values may be obtained by the use of a test plate of known reflectance and a brightness meter for stable conditions or by cosine- and color-corrected photocells for stable or unstable conditions (with neutral density filters as needed). Incident illumination values for illumination from above the horizontal excluding sun and from below the horizontal may be obtained by placing a black area such as velvet below or above the test plate or photocell. The sun can be excluded from measurements by shielding the test plate or photocell from the sun only. Incident illumination from the sun only may be obtained by subtracting the illumination of the sky and ground from the total incident illumination.

(7) Sky brightness readings should be made at the horizon, 45-degree and 90-degree altitudes and at 0 azimuth, 45 degrees to the right and 45 degrees to the left of normal to all fenestration areas.

(8) Reflectances may be obtained with the brightness meter and a test plate of known reflectance or by comparison methods, such as standard color chips.

(9) Each interior reading must be taken simultaneously with a total incident illumination reading in the plane of the fenestration or at the outer edge of any control device.

(10) Interior readings may be taken with cosine- and color-corrected photocells mounted on the work plane, walls, and ceilings or with a brightness meter and a test plate of known reflectance.

1.5—*Test Report* — The test report should present all the significant data in a manner that will permit comparisons with other tests and existing prediction techniques. It should include the following:

1.5.1—*Description of Installation and Conditions*

(1) Date of test and time of test.

(2) Location (state, city, street, and number, and room or rooms tested).

(3) Instruments used to record test data and when calibrated.

(4) Name of person taking test and who tests were taken for.

(5) Orientation of room and fenestration.

(6) Fenestration—type glass, transmittance, and net transmission area.

(7) The room dimensions including length (parallel to window wall), width, ceiling height, and sill height.

(8) Control — A description of all illumination controls and their adjustment, if any.

(9) Interior conditions, such as equipment and interior reflectances. A sketch or photograph with the reflectances shown is desirable. See Fig. 2.

(10) Exterior conditions — A description of the exterior conditions including sky conditions, sun conditions, and ground conditions. Where there are large areas of different reflectances affecting the incident illumination on the fenestration, a sketch or photograph showing these areas and their reflectance or brightness is desirable.

1.5.2—*Photometric Data*

(1) Tabulation of average exterior brightness readings and illumination values with the maximum and minimum deviation.

(2) Tabulation of interior brightness readings. This is better illustrated with a perspective view of the interior room, showing the readings on the sketch or photograph as shown in Fig. 1. All readings should be adjusted to an average exterior illumination value.

2. Sample Report of Daylighting

Date of Test _____ Time of Test _____
Location of test _____
_____
Instruments used to record test data
(a) Brightness _____ Date of Calibration _____
(b) Illumination _____ Date of Calibration _____
Test taken by _____
Test taken for _____

I. Description

A. Fenestration
1. Orientation _____
2. Type _____
Transmittance of glass _____
Net Transmission area _____
3. Room dimensions _____
B. Controls _____
_____
_____
C. Room Conditions _____
_____
D. Exterior
1. Sky Conditions _____
2. Sun Conditions
Altitude _____ Azimuth _____
4. Ground Conditions _____

II. Exterior Measurements

A. Illumination Values in Footcandles
1. (a) 1st _____ 2nd _____ Average _____ Total Incident Illumination measured in the plane of each fenestration area at the outer edge of any control devices.
(b) 1st _____ 2nd _____ Average _____ Incident Illumination from the sun only at _____ altitude _____ azimuth from normal.
(c) 1st _____ 2nd _____ Average _____ Incident Illumination from the horizontal excluding sun.
(d) 1st _____ 2nd _____ Average _____ Incident Illumination from below the horizontal.
2. 1st _____ 2nd _____ Average _____ Total Incident Illumination measured on a horizontal plane in an unobstructed position.

B. Brightness Measurements in Footlamberts
1. Sky Brightness

Altitude	Horizon	45°	45°	45°	90°	
Azimuth	45°L	0°	45°R	45°L	0°	45°R	0°
1st							
2nd							
Average							

0° Azimuth taken as normal to fenestration area.
2. Vertical Surfaces — If there are large vertical surfaces affecting incident illumination on fenestration show sketch or photograph with average brightness values and dimension.

C. Ground
1. Average Reflectance of Ground _____
If there are large areas of different reflectances such as walks, play areas, or streets immediately adjacent to the fenestration, show sketch or photograph with reflectances and dimensions.

III. Interior Measurements

A. Illumination values (corrected to average incident illumination). See Fig. 1.
B. Reflectances. See Fig. 2.

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Comment — This paper gives the four sky conditions for daylighting measurements as well as tackling the problem of saw tooth design.

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Comment — This paper discusses the shading effect of exterior buildings in the vicinity of fenestrations.

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Comment — This paper discusses dirt collection on windows.

7. Vogel, A., Randall, W. C., Martin, A. J., and Benford, F.: "Daylighting in Multi-Story Industrial Buildings," *Transactions of the I.E.S.*, Vol. XXIII, No. 2, p. 129 (February 1928).
Comment — Under "Field Tests," part 3, of this paper, there is a description of using a stationary photometer for adjusting test readings.

8. Rapp, George M., and Baker, A. H.: "Daylight Illumination on Interiors Fenestrated with Glass Blocks," Illuminating Engineering, Vol. XXXVI, No. 10, p. 1129 (December 1941).
Comment — Comparative information is given in this paper on the value as a datum of reference of readings taken by Sill Ratio meter, vertical surface meter and sphere illuminometer.

9. Greene, B. F.: "Natural Light Reflected from Ceiling," Illuminating Engineering, Vol. XLI, No. 6, p. 474 (June 1946).
Comment — This paper is based on theory, but is important in that it shows the necessity of considering light reflected from the ground.

10. Moon, Parry, and Spencer, Domina: "Illumination from a Non-Uniform Sky," Illuminating Engineering, Vol. XXXVII, No. 10, p. 707 (December 1942).
Comment — This paper is theoretical but gives a means of calculating the variation in the distribution as between a uniform sky and the defined non-uniform sky. A check on variations reported experimentally.

11. Folsom, W. E., and Biesele, R. L., Jr.: "The Measurement of Illumination and Brightness in a Classroom," Illuminating Engineering, Vol. XLIII, No. 4, p. 355 (April 1948).
Comment — This paper describes the use of a meter stationed at a fixed point near the center of the room as a datum of reference.

12. Biesele, R. L., Jr.: "Daylight in Classrooms," Illuminating Engineering, Vol. XLV, No. 7, p. 445 (July 1950).
Comment — Biesele describes the use of meter readings on the plane of the fenestration as datum of reference by which to reduce illumination readings to a common basis.

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Comment — This paper shows a particular way of using the data furnished by a meter located in a fixed position in adjusting illumination readings to a common basis.

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E. W.: "The Importance of Ground Reflection in Daylighting." ILLUMINATING ENGINEERING, Vol. XLVIII, No. 1, p. 35 (January 1953).
Comment — This paper stresses the importance of ground light.

15. Billhartz, W. H., Kingsbury, H. F., McKinley, R. W.: "A New Daylighting Survey Technique Utilizing a Photographic Recorder and Physical Brightness Meters." ILLUMINATING ENGINEERING, Vol. XLVIII, No. 1, p. 6 (January 1953).
Comment — This method has value for the specialist but requires a large investment in instruments.

16. Vezey, E. E., Reed, Bob H., and Evans, Ben H.: "Daylight Survey Methods." ILLUMINATING ENGINEERING, Vol. XLIX, No. 5, p. 245 (May 1954).
Comment — The results are expressed in terms of daylight factors defined as the ratio of the illumination at a station to the simultaneous illumination on the vertical plane of the fenestration. A maximum deviation from the average daylight factor for all types of sky was in the order of 25 per cent for the positions studied. A method was given for separating ground component of the daylight factor from the sky component.

17. Reed, Bob H. and Nowak, Matthew A.: "Accuracy of Daylight Predictions by Means of Models Under an Artificial Sky." ILLUMINATING ENGINEERING, Vol. L, No. 7, p. 336 (July 1955).
Comment — This paper describes the testing technique used at the Texas Engineering Experiment Station.

18. Griffith, J. W., Arner, W. J., Conover, E. W.: "Daylighting Design with Overhangs." ILLUMINATING ENGINEERING, Vol. LI, No. 3, p. 241 (March 1956).
Comment — This paper describes the photographic recording technique used at Southern Methodist University.

How Much Does Lighting Decrease?

A record of footcandle readings taken at various fluorescent lighting installations in and around San Diego, California, by the Commercial Lighting Department, San Diego Gas and Electric Company.

Installation	Square Footage Involved	First Reading Average Footcandles	Second Reading Average Footcandles	Per Cent Lighting Decreased	Comments
1. Bank	4,560	143 after 100 hours	115 after 2 years	20%	Plastic louvered fixture. Maintenance good. No plastic discoloration.
2. Shoe Store	376	40 after 30 days	34 after 1½ years	15%	Closed plastic bottom fixture. Maintenance good. No plastic discoloration.
3. Dress Shop	800	50 after 1 year	40 after 4 years	20%	Plastic louver fixture. Maintenance good.
4. Cafe	1,008	76 after 30 days	55 after 3½ years	28%	Closed plastic bottom recessed troffer fixture. Maintenance fair. Plastic showed a slight discoloration.
5. Office	2,812	48 after 30 days	39 after 3 years	19%	Louvered bottom fixture. Maintenance good.
6. Malt Shop	672	70 after 30 days	39 after 5½ years	45%	Louvered bottom fixture. Plastic yellowed. Maintenance poor — dirty.
7. Clothing Store	2,552	40 after 60 days	31 after 2½ years	23%	Luminous plastic ceiling. Maintenance good.
8. Gift Shop	1,488	79 after 30 days	54 after 2 years	32%	Closed plastic bottom fixture. Original lamps being used. Maintenance good.
9. Beauty Shop		60 after 30 days	43 after 1½ years	29%	Louvered fixtures. Maintenance good.
10. Savings & Loan Co.	1,580	80 after 30 days	82 after 2½ years		Lens bottom fixture. All new lamps installed the week before. Maintenance good.
11. Drug Store	1,936	80 after 30 days	65 after 1 year	19%	Louvered fixtures. Maintenance excellent.
12. Office	783	70 after 30 days	56 after 1½ years	20%	Indirect 800 ma fixture. Maintenance good.
13. Drug Store	985	75 after 30 days	45 after 4 years	40%	Louvered fixture. Original lamps being used. Maintenance fair.
14. Office	1,157	107 after 6 months	52 after 5 years	51%	Indirect fluorescent. Maintenance poor — dirty fixtures.
15. Appliance Store	1,947	50 after 1 year	40 after 2½ years	20%	Recessed troffer fixture. Maintenance good.
16. Library		70 after 60 days	53 after 3 years	25%	Closed plastic bottom fixture. No discoloration. Maintenance good.
17. Music Store		84 after 30 days	78 after 4 years	7%	Louvered fixtures. Maintenance good.
18. Jewelry Store	406	274 after 30 days	181 after 3 years	34%	Louvered plastic ceiling. Maintenance poor.

Views and Opinions

Hazards and Pitfalls in Footcandle Calculations

It seems that everything is getting more scientific. In the old days if three watts per square foot were provided for lighting, a "good job" would result. Now, practically anyone in the lighting business can predict footcandles based on the lumen method of calculation. Most equipment manufacturers provide coefficients of utilization; by solving a simple formula or by looking at a trick slide rule, the "resulting footcandles" are shown. When the actual job is installed, however, and a measurement taken, it is often found that calculations and footcandle readings do not agree. What went wrong, assuming that no mathematical error was made? Accuracy of advance calculation is important, in this competitive day. Designers may be caught between the landlord of a building and a tenant, an insurance company, say, which has a lease clause stipulating that 50 footcandles of shielded light must be provided. Some unions have clauses that "adequate" light must be provided for the workers. Now, if too much of a safety factor is provided, the building management will complain that they have bought more than is necessary. If several contractors are bidding a job to guarantee a certain number of footcandles, they may base the bid on a certain number of luminaires. It is apparent that there can be a wide variation. At this point an engineer may be called in.

For accurate calculations, ten principal factors must be considered. They are listed below, not necessarily in the order of importance. (These items are based primarily on fluorescent equipment.)

(1) Lamp output
(2) Ballast characteristics
(3) Room index errors
(4) Room reflectances
(5) Maintenance Factors
(6) Errors in the method of measuring "average" footcandles
(7) Footcandle meter errors
(8) Coefficients of utilization
(9) Interference factor
(10) Ignorance multiplying factor.

In many cases the errors balance out between the pessimistic and optimistic variables. Of course, all the above points may not enter into every calculation.

(1) *Lamp Output.* There are now nine different white lamps listed. Each manufacturer shows a different lumen rating, depending on how recent his charts are. We must make sure that the lumen rating used in our calculations are the ones that were installed on the job. Lumen ratings are based on operations after 100 hours. Before that time the output can be up anywhere from 1 to 15 per cent. It is quite unpredictable. Usually the lumen ratings are assumed at 77 degrees ambient temperature even though this may not be where the maximum light output is. Also, it is assumed that the lamps are in still air. On the higher current lamps such as the 800ma types, the lumen output goes down rapidly as the ambient temperatures go up. The maximum light output has been designed around 40 to 50 degrees.

(2) *Ballast Characteristics.* The purpose of the ballast is two-fold. One, to limit the current through the lamps, and two, to provide the proper starting voltage. The input voltage to the ballast affects the light output. Lead-lag ballasts are more sensitive to voltage change than series types. For every one per cent change in input voltage above and below the design voltage, the light output will vary one per cent with lead-lag ballasts, whereas series ballasts change one-half of one per cent. In a test it was found that various ballasts operating at their rated voltage varied the lamp output from 87.5 to 110.5.

(3) *Room Index Errors.* With newer charts now available there is very little chance of variance. However, on some of the older charts a big error could result between the B and C index when the ceiling height varies by only 12 inches. A 25 per cent error was possible. The line of demarcation between general diffuse and semi-indirect is not always too clear, and what a difference it makes on the room index! The reason is that in one case the ceiling height is used whereas mounting height is

the criteria. The safe way is to use the "room ratio equation." One should be careful, however, as it is based on distances from the work plane rather than from the floor as was the case of the latter system.

(4) *Room Reflectances.* Most room index charts are based on room reflectances having a 75 or 50 per cent ceiling with 50, 30 or 10 per cent walls. Usually the floors are based on 14 per cent. In later charts, reflectances shown are 80, 70 or 50 per cent ceilings with either a 10 or 30 per cent floor reflectance. With direct lighting systems and smaller rooms, the floor reflectance is of little consequence but caution should be exercised on indirect systems with large rooms. It is possible to be in error by as much as 15 per cent with incorrect floor reflectance figures.

Many times the walls have been painted one to three feet down from the ceiling with high reflectances or the same as the ceiling. In this case as much as 10 per cent increases in footcandles may result. Again, we must be careful with large wall areas that are of glass. Although the walls may be painted with 50 per cent paint, the overall average is less, due to the light transmission through the glass. We should weigh the relative areas and the reflectances when several different reflectances are used. Remember that the holes in acoustical tile occupy about 20 per cent of the area, thereby decreasing the average reflectance.

(5) *Maintenance.* Here is one item which causes a tremendous controversy. Eastern influence puts the maintenance factor low. In the west we don't take into account that some of the lamps are not burning when determining this factor. The maintenance factor includes light output depreciation, dust on the lighting equipment, normal paint fading and the fact that an equal amount of old and new lamps are in the system. Generally speaking a figure of .7 is a safe maintenance factor to use but in some cases this is too pessimistic.

(6) *Footcandle Meter Errors.* Normally, the small pocket meter is used. Experience shows that this is a rugged little instrument but it does have its shortcomings. For example, at midscale it is accurate to within about three per cent but at either extreme end, it is quite unpredictable. For those older ones that use a multiplying cover, the two scales would never agree. These meters were not color or cosine corrected, thereby introducing a serious error, depending on the color of the lamps used or the relationship between the room index and the luminaire distribution.

Nowadays all measurements and calculations are based on color-cosine corrected meters. Unfortunately every model varies, and it is difficult to figure out which is the right meter. One might assume that the latest one is the most accurate but this isn't necessarily true.

(7) *Errors in Measuring the "Average" Footcandles.* This is probably one of the worst offenders and the one factor most often missed. Technically, the average footcandles in the room means that if all the readings were taken on each square foot, then divided by the total number of readings, it would represent the average. Unfortunately this is impractical, so the IES has devised a simpler method which will give a ten per cent accuracy. It is still rather complicated and has not been widely accepted. An excellent system in large rooms is to strike an imaginary line from an end wall and parallel to it one-quarter of the total room length. Starting from the center of the room, take a reading at work plane height, one directly under the row of fixtures (unless there is a row in the center), one half way between, etc., until you reach the last row. The next reading is between this and the wall. Plot these readings on graph paper. Theoretically, if a line is drawn so that the same area is above and below the curve, this line with represent the average weighted footcandles. With this measuring system, it is possible to prove that if one reading is 100 and another 50 footcandles, the resulting average is not necessarily 75.

(8) *Coefficients of Utilization.* This has been the real trouble maker between the predicted footcandle values and those actually measured in the field. Many designers will look at a lamp company guide sheet for coefficients, others at the *IES Handbook*. It is difficult to judge a luminaire by the rough illustrations. They may look alike but have serious differences in distribution. Assume that this trap weren't fallen into and the manufacturers' published coefficients were used, could they have been in error?

Yes. For years they have used mathematically based charts which had a basic error. This was reflected throughout the calculations. Recently the IES has adopted a new system for coefficient of utilization calculation. This is the Zonal Interflectance method; it is the approved method and the only one recognized by the IES as the proper one.

Under the previous Anderson-Harrison method, serious errors resulted in larger rooms with high indirect components. The new system is very realistic and accurate. The amount of computation for determining C.U.'s with the Z.I. method, however, is tremendous. Roughly, the ratio of work is about 8 to 1 between the two methods. Smaller equip-

ment manufacturers are reluctant to accept the expense of such time. In some cases, manufacturers do not like to publish new catalog pages showing the recognized standard. The lighting application engineer, however, must ascertain what method was used by the manufacturer for his C.U. charts. When the new Z.I. method is used, it will probably be shown in large, bold letters. If nothing is mentioned, it is ten to one that the Anderson-Harrison system is shown. A difference of 50 per cent can result under certain conditions between the footcandle calculation using one or the other system.

(9) *Interference Factor.* This takes into account the interference of light due to columns, partial partitions, file cabinets and other obstructions. It must be remembered that all calculations are based on open rooms. Each designer has to weigh his own multiplying factor to take such interferences into account. As a guide, partial partition interference is more prevalent with indirect systems than with strong downward components. Actually this is a subject by itself.

(10) *Ignorance Factor.* This is a real item. It might be thought of as the factor that is applied when the design conditions cannot be found in standard charts or handbooks. For example, one is asked to compute the footcandles in a bank where there are two continuous rows of luminaires over the work areas on both sides of the room. The customer lobby area in between receives only spill light. Your client wants to know the footcandles in the general work area, one for the counter tops directly under the luminaires and one in the lobby area. How to select the room index? What size room to select for the area figure? Is the lumen method for computation adequate? Is there some other system? Or can we approximate something and then apply an ignorance factor? Each designer has his own pet method and all of them are subject to discussion, depending on the accuracy desired. There are two methods which are excellent, but which are not "clinically" correct.

Although this discussion is primarily based on the accuracies of footcandle calculation, it must be mentioned that lighting comfort is very important. In fact, the entire visual environment should be influenced by the lighting designer.

There has been no fully accepted way of mathematically evaluating the comfort or glare. There are several methods now being used. One, for example, is the Meaker Glare Factor technique. This method takes into account the brightness of the sources, surrounding brightness, area of the source and the relative location of the source to the observer. By mathematically solving this relationship, glare is given in the form of a number. This figure means very little by itself until it is applied to another chart known as the Visual Comfort Index. This index states that if the glare factor is a certain number, then a certain percentage of the occupants will be visually comfortable. The most disadvantageous position in the room is assumed. The purpose of the glare factor is to compare various lighting systems to determine which one will result in greatest comfort.

It is up to the equipment manufacturer to state what the glare factor will be. There is a certain hesitancy on the part of industry to accept glare factors. It is felt by some that should one piece of equipment be rated at, say, 15 and another at 18, the figure will be used against them commercially, rather than be properly appraised by an expert. It can be a dangerous tool in the wrong hands. It must be remembered that glare factors only tell what the direct glare will be and this particular formula is not applicable to reflected glare. I know of no method which mathematically appraises reflected glare. Several have been proposed but they all have had numerous deficiencies. — EDWARD BALOGH, *Sunbeam Lighting Co., Los Angeles, Calif. Substance of a talk before the South Pacific Coast Region of I.E.S.*

Applications for Retired Membership

By action of the membership of I.E.S., retired membership classifications are available to those members qualified. Privileges in these grades, earned by long membership in the Society, include reduced annual dues ($5.00) with the continued receipt of all Society mailings including ILLUMINATING ENGINEERING. Classifications are known as Member, Retired; Associate Member, Retired.

Those who are interested and qualified (at least thirty years of membership in the Society and 65 years of age) should communicate with the General Secretary at Society Headquarters, stating that they have retired from regular occupation in business or profession.

Here and There with I.E.S. Members

At the February meeting of the Mid-South Chapter, held in Memphis, Tenn., R. F. Ridenour, Program Committee Chairman, talks with principal speaker, Benjamin Duhov, Westinghouse Lamp Engineer, following his discussion on "Mercury Vapor Lighting — Past, Present and Future."

"Applying the Fundamentals of Light and Vision to Industrial Lighting" was the topic of the Michigan Section's January meeting. Shown here: Floyd Sell, speaker; Henry A. Cook, Program Chairman, and James F. Finn, Section Chairman. Attendance was 150.

Despite the stormiest weather of the winter, nearly 200 Montreal Section members and guests turned out for the February 19 joint meeting of the Section and the Electrical Club of Montreal (photo at left). Honored guest and principal speaker was I.E.S. President Kirk M. Reid, who spoke on "Illuminating Engineering — Its Place in the Electrical Industry," tracing the development of the industry from the days of Edison to the present, and on the research projects being sponsored by the Illuminating Engineering Research Institute. In photo below left, l. to r., seated: Eric S. Bushell, Chairman of the Electrical Club of Montreal; I.E.S. President Kirk M. Reid; William P. Beazley, Chairman of the Montreal Section, I.E.S.; standing: Fred Patterson, Managing Secretary, Electrical Club of Montreal; Vic Labbe; Bob Bailey, Canada's Electrical Man of the Year; John E. Shepherd; Joe Thomas, Past Canadian Regional V-P; Bill Massie; Bob Thomas; Bruneau Amyot; and R. H. Hall.

LIGHTING NEWS

Research Symposium Presents New Basis for Footcandle Requirements

Eight years' extensive research at the University of Michigan establishes a method of determining, scientifically, illumination levels needed for specific seeing tasks. Wide variation is indicated by all tests to date.

Many current concepts for recommended lighting levels may be in for drastic modification — in both directions. This was the incontrovertible conclusion of the RQQ Committee and of members of IES Technical Committees, after studying the evidence of researches recently completed at the University of Michigan. Results of these studies were presented by Dr. H. Richard Blackwell, Director of Vision Research Laboratories, University of Michigan, at the Research Symposium held at Dearborn Inn, Dearborn, Mich., March 3 and 4. The two-day meeting, sponsored by the Illuminating Engineering Research Institute was attended by 122 people — scientists and engineers, a great majority of them members of interested IES committees.

Complete details of Dr. Blackwell's research techniques and findings, and their significance in lighting application will be presented in his Research Project paper, to be published in a subsequent issue of ILLUMINATING ENGINEERING. And for those interested in further detail now, a transcript of the complete symposium on tape recording may be obtained from C. L. Crouch, IES headquarters.

The symposium report on his work, requiring most of the first day, presented a detailed description of the research, sponsored by IERI, underway continuously since 1950. A brief outline of his presentation would include:

1. Analysis of essential characteristics of visual performance.
2. Performance data for a set of standard visual tasks.
3. Suprathreshold visibility factors.
4. Apparatus used — Visual Task Evaluator.
5. Recommended illumination levels for 56 practical visual tasks (based on their evaluation with his apparatus).

SPONSORS — guiding officers of the Illuminating Engineering Research Institute: C. L. Crouch, Secretary; A. F. Wakefield, Chairman, Board of Trustees; Dr. H. R. Blackwell, University of Michigan, director of the researches on quantity of illumination; Prof. E. M. Strong, Symposium Chairman.

Engineers in the audience were fortunate in Dr. Blackwell's remarkable ability to present scientific data in a most articulate, if not to say colorful, manner. Details of APS, assimilations per second (of information through vision), oculomotor aspects of seeing and other biological concepts are not daily considerations in their work. Nevertheless, the proverbial pin could have dropped, and this for many continuous hours.

Of particular interest to them was, of course, the detailed description of the techniques, basis, and apparatus used to answer the question — "How much light, exactly, is needed for any given task?" For a visual accuracy of 99 per cent (the highest practical), this question was answered for 56 practical visual tasks, and a basis established for determining illumination level requirements for other similar tasks, which ranged from easy through ordinary, to difficult or very difficult seeing tasks.

Dr. Blackwell's presentation was followed in the late afternoon with a glimpse

Dr. H. R. Blackwell

Professor Mathew Alpern

Dr. S. K. Guth

Dr. Glenn A. Fry

of another research project which may, in due time, have further far-reaching effects on lighting recommendations. This was the discussion by Dr. Mathew Alpern, Assistant Professor of Ophthalmology, University of Michigan, of his studies on the "Relation of Illumination to Ocular Focusing and Fusion of Images." This work is still underway, but two curves he was able to present at the symposium held rather exciting possibilities to further corroboration of the answers to the question of "How much light is required" — and why. These data showed how low levels of illumination and/or difficult visual tasks, affect the ability of the eye to focus, and other ophthalmological effects.

On Monday's program also was Dr. Glenn A. Fry, Professor of Psychology and Physiological Optics, and Director of the School of Optometry, Ohio State University. Dr. Fry described, in detail, the development of a portable meter for measuring disability glare.

Questions from the floor, following each presentation, were of course, rapid-fire; discussion, brisk. Practicing engineers were eager for rock-bound maximums and minimums.

Recommendations for the applications of the principles presented were undertaken, during two all-night sessions at Dearborn, by the IES Committee on Recommendations for Quality and Quantity of Illumination, Benjamin S. Benson, Jr., Chairman. Report No. 1 of this committee presented to the technical committees the following day, may well turn out to be historic as well as heroic. Laboring throughout the night on Sunday, March 2, and again through Monday night, the committee presented dittoed copies of their recommendations to the technical committee members at the Tech-

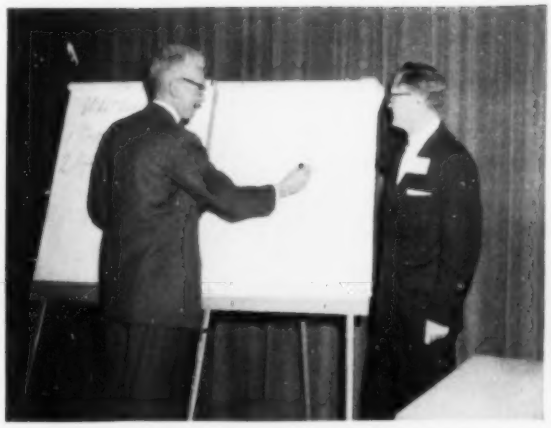
Dr. L. C. Mead, Tufts University

Benjamin S. Benson, Jr.
Chairman, RQQ Committee

Prof. Dan Finch, Hedley F. Davidson, John M. Chorlton

The halls were buzzing with rump sessions following Dr. Blackwell's historic presentation . . .

Cornering him for further details are (facing camera) Kirk Reid, IES President and E. M. Strong.



Kirk Reid and George J. Taylor, IES First Vice-President, figure it out.

A. F. Wakefield and E. M. Strong get an explanation.

Professor Dan Finch comments on the problem.

At the Technical Committee Forum which followed the Symposium, chairmen of IES technical committees (in audience) heard and discussed the recommendations of the RQQ Committee (on the platform) for new footcandle levels, under the direction of George J. Taylor, Chairman (at rostrum). At a table, center front of the platform were (l. to r.) Dr. Blackwell, Mr. Crouch, and Prof. Finch. Left to right on the platform are RQQ members: Ernest Boghosian, Willard Allphin, Lester Geis, Frank Merriott, W. H. Kahler, John Chorlton, Kirk Reid, (G. J. Taylor), B. F. Benson, Jr., S. K. Guth, W. W. Weld, W. S. Fisher, L. V. James, Dana Rowten, E. M. Strong

Tape recordings of the entire proceedings at the Symposium were made by John E. Kaufman, technical assistant to Mr. Crouch at IES Headquarters.

Registration for the 122 delegates was handled by Janet Anthony, Technical Office, IES Headquarters Her customers at the moment: A. W. Fowle and E. H. Church.

nical Committee Forum held Tuesday afternoon. George J. Taylor, IES First Vice-President, was chairman of this history-making meeting. On hand also at the Technical Committee Forum, for questions, answers and discussion, were Professor Blackwell, C. L. Crouch and Professor Dan Finch (see cut).

Report No. 1 of the RQQ Committee as drafted in pencil by Chairman Benson, was rushed into type by Janet Anthony, secretary to C. L. Crouch, the stencils whisked to Detroit by James Finn, run off as a crash project and distributed to all attending the Tuesday afternoon Forum. While this all seemed as effortless as breathing, such extraordinary dispatch and cooperation deserves mention, to say the least.

For the record, text of this report is included at the end of this item, with the exception of the tables. The values recommended in these tables were further studied by various application committees of IES throughout Wednesday, March 5. The recommendations of the committees for footcandle levels to apply for specific areas and specific tasks (school, office, industrial, residential, etc.) using the RQQ recommendations as guidance will be reflected in the new footcandle tables now being developed for the *IES Lighting Handbook*.

Details of the "Quantity" presentation Monday, and its impact on the Technical Committee Forum, Tuesday afternoon, should not, by any means, over-shadow the extremely interesting symposium session held on Tuesday morning. Presented in two parts, this symposium covered studies aiming at the solution of practical lighting problems. Part I, Measurement of Contrast Losses in School and Office Tasks, featured two such studies: Professor Dan M. Finch discussed work completed at the University of California, and a team representing the Board of Education, Toronto, Ont., John M. Chorlton and Hedley F. Davidson, described their work, and findings in such measurements in Toronto classrooms. Part II, Measurement of Discomfort Glare, completed this symposium. For this, Dr. S. K. Guth described a new portable instrument for use in this aspect of illuminating engineering.

In detail, the symposium program was as follows:

Monday, March 3, 1958

Chairman: Prof. E. M. Strong, Cornell University

Our Second Symposium — address of welcome by A. F. Wakefield, Chairman, Board of Trustees, IERI.

A Doctor Looks at Light by Conrad Berens, M.D., Executive Director, The Ophthalmological Foundation.

Research Scores Again by Prof. Strong.

New Method for Determining Illumination Levels by Prof. H. Richard Blackwell, Director of Vision Research Laboratories, University of Michigan, Ann Arbor.

Measuring Disability Glare with a Portable Meter by Prof. Glenn A. Fry, Professor of Psychology and Physiological Optics in Physics and Astronomy, and Director of the School of Optometry, Ohio State University, Columbus.

Relation of Illumination to Ocular Focusing and Fusion of Images by Prof. Mathew Alpern, Assistant Professor of Ophthalmology, University of Michigan, Ann Arbor.

Dinner — Speaker: Stanley S. Ballard, Executive Secretary, Armed Forces — NRC Committee on Vision — Topic: "Visible Light."

Tuesday, March 4, 1958

Chairman: Prof. Glenn A. Fry.

Solving Practical Lighting Problems by C. L. Crouch, Secretary IERI.

Measurement of Contrast Losses in School and Office Tasks

Studies at the University of California by Prof. Dan. M. Finch, Professor of Electrical Engineering, University of California, Berkeley, Calif.

An Example from Toronto Schools by John M. Chorlton and Hedley F. Davidson, team representing the Board of Education, Toronto, Ont.

Measurement of Discomfort Glare

A New Portable Instrument by Sylvester K. Guth, Manager, Radiant Energy Effects Laboratory, Nela Park, Cleveland.

Report #1
I.E.S. Committee on Recommendations for Quality and Quantity of Illumination

A new system of determining the illumination level recommendations has been presented to the Society by the Illuminating Engineering Research Institute.

The method results in the establishment, for a quantity of practical seeing tasks, a series of 4-minute standard test objects of equivalent degrees of contrast. These equivalent values all lie on a curve relating required task brightness to the contrast values corresponding to the following conditions:

A. Visual capacity of 5 assimilations per second (APS)

B. 99% accuracy (maximum practical accuracy)

C. Suprathreshold visibility factor of 15.

For purposes of use by the technical committees of the Society, the values of equivalent contrast have been divided into five categories representing five general levels of task difficulty. The first cate-

Committee meetings by the score were held Wednesday, March 5 to apply, for specific areas, footcandle levels indicated by the Blackwell studies and/or the recommendations of the Committee on Recommended Quality and Quantity of Illumination. A few of the several such meetings are shown here.

Residence Lighting Committee

Nomenclature Committee

gory represents contrast values which require task brightness values of less than 18 footlamberts. The range of contrast values requiring more than 18 footlamberts was divided into four equal categories in terms of contrast values. The task designations arbitrarily selected to describe these tasks, and the range of corresponding brightness values are shown in Table I.

The 56 practical visual tasks actually studied are listed in Table II in terms of task difficulty obtained by actual measurement and serve as a basis for the classification of unrated tasks.

Instructions for Use of Data

1. In any given location the seeing tasks should first be studied to determine if more than one is involved. Where a combination of tasks of varying degrees of severity is encountered, select the one that is the commonly used, most difficult task.
2. From Table II find tasks that are most nearly comparable to the unrated task and select the corresponding brightness factor in footlamberts.
3. Divide this brightness factor by the reflectance of the unrated task to determine the range of footcandles.
4. In establishing the recommended illumination value, engineering judgment based on economic factors should be considered.
5. In all locations involving visual tasks, levels of less than 30 footcandles do not appear desirable. Incomplete data on oculomotor adjustment functions suggest the undesirability of low brightness values. In addition, considerations of maintaining adaptation between one task

(*Continued on page* 16A)

Industrial Lighting Committee

Light Control and Equipment Design Committee

RIBBONS OF LIGHT—Sylvania recessed troffer lighting can be mounted in continuous rows and spaced for desired high lighting levels in modern business offices.

Introducing . . .

a new Shallow Troffer Series by Sylvania— recessed lighting for today's building methods

For the aesthetically minded lighting designer, who has to cope with the modern trend to lower ceilings and shallower plenum spaces . . . here is a new approach to recessed lighting. It's Sylvania's new Shallow Troffer Series, fixtures which measure only 5½" from top to bottom—and, in many cases, require no more space than that for mounting!

Available in a variety of models, in both one- and two-foot widths, the Sylvania Shallow Troffer makes this popular form of lighting *practical and usable* in all new buildings, with full illumination efficiency. The units are fully recessed. Unsightly latches are buried. Even the hinges don't show . . . only the clean straight lines of the exposed portion of the framing, and the attractively styled shielding.

Sylvania Shallow Troffers are carefully engineered to utilize the full plenum space. Lay-in type troffers are provided for Z-spline and inverted-T ceilings. Exclusive *snap-up hanger* provides quick, secure mounting for most other types of acoustical ceilings (see sketches below). Ask your Sylvania Fixture Specialist for full details, or write direct for FREE new folder of specification data.

SYLVANIA ELECTRIC PRODUCTS INC.
Dept. D30, Lighting Division—Fixtures
One 48th Street, Wheeling, W. Va.

SYLVANIA

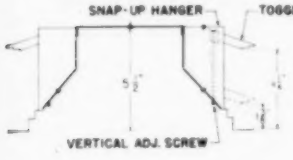
Fluorescent Lighting Fixtures and Systems

Best fixture value in every price range

LIGHTING • TELEVISION • RADIO • ELECTRONICS • PHOTOGRAPHY • ATOMIC ENERGY • CHEMISTRY-METALLURGY

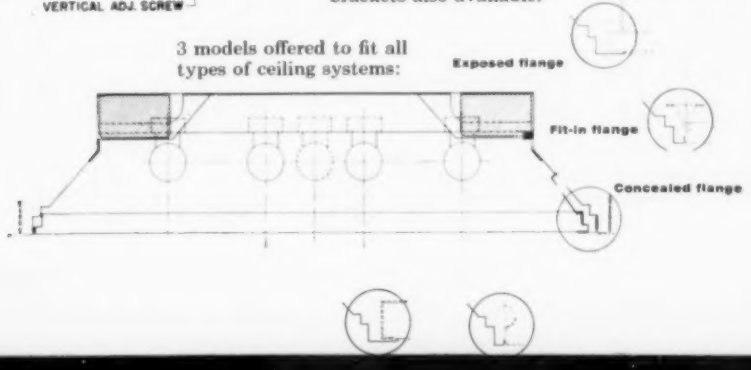
INDIVIDUALLY MOUNTED troffers, imaginatively arranged, combine attractive design with good basic light distribution for company cafeterias and lounges.

STRIKING, PLEASANT ACCENT for an up-to-date building corridor: Sylvania recessed lighting troffers continuous-row mounted with acoustical ceiling materials.

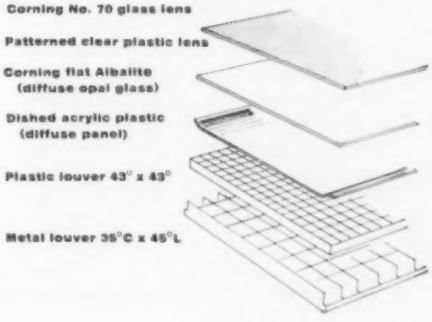


NEW 5½" HIGH TROFFER utilizes full plenum space. Exclusive *snap-up hanger*, with vertical adjusting screw, provides secure side-mounting for acoustical ceilings with support elements parallel to troffer. End-mounting brackets also available.

3 models offered to fit all types of ceiling systems:



ALL STANDARD TROFFER SHIELDINGS


Corning No. 70 glass lens
Patterned clear plastic lens
Corning flat Albalite (diffuse opal glass)
Dished acrylic plastic (diffuse panel)
Plastic louver 43° x 43°
Metal louver 35°C x 45°L

(Continued from page 13A)

During the group dinner on March 3, an award for outstanding services to lighting research was presented to Dr. Stanley S. Ballard (left), Executive Secretary, Armed Forces NRC Committee on Vision. A. F. Wakefield made the presentation on behalf of the IERI.

and another suggest that a lower limit should be placed.

6. Consistency of illumination values should be checked.

7. In selecting an illumination value, it is recommended that it be fitted into the following sequential order:

10, 15, 20, 30, 50, 70 and 100

× 0.1
× 1.
× 10.
× 100.
× 1000.

} as required

8. In determining illumination values for service areas, it is recommended that such be not less than 1/5th that in adjacent areas. Each committee should decide specific values for such areas in relation to the adjacent area illumination to be encountered in their particular field. In no case should such illumination be less than 10 footcandles. Included in service areas are the following:

Elevators
Lobbies
Hallways
Storage
Washrooms
Stairs and landings.

9. While most seeing tasks fit into categories that fall naturally under the scopes of the various technical committees, there are a few borderline cases which it is recommended be undertaken by the following committees:

Task	Committee
Armories	School
Art Galleries	Institutions
Auditoriums (other than theaters)	School
Automobiles (parking and showrooms)	Store
Banks	Office
Churches	Institutions
Club and Lodge Rooms	Institutions
Court Rooms	Institutions
Dance Halls	Sports and Rec. Areas
Depots, Terminals and Stations	Office
Drafting Rooms	Office
Libraries	School
Municipal Buildings (fire and police)	Office
Museums	Institutions
Post Offices	Offices
Professional Offices	Institutions

Illustration of Method

In Table III is shown a suggested table of school lighting tasks determined on the above described basis and included as a guide.

Respectfully Submitted,
I.E.S. Committee on Recommendations of Quality and Quantity of Illumination
B. S. Benson, Jr., *Chairman*

French I.E.S. Meets At Reims Conference

The Association Francaise des Éclairagistes are holding their annual conference at Reims, April 23 to 26, with technical sessions and tours of the city and environs. Topics covered by the various speakers include the teaching of illumination in France and other countries, colorimetry and its application in perceiving and identifying signal lights, current doctrines and trends in lighting of public areas in several countries and, during the closing session, a discussion of the lighting at the World's Fair in Brussels.

As is usual at the French meetings, the principal monuments of the conference city will be floodlighted, and tours to local factories and outstanding lighting installations have been arranged.

A.F.E. has announced the availability of the Proceedings of last year's conference, which was held in Lyons. The 235-page illustrated publication may be obtained from l'Association des Éclairagistes Francaise, 33 rue de Naples, Paris 8e; price, 2000 francs.

Ottawa Section Sponsors Kingston Extension Meeting

An enthusiastic group of engineering students from Queens University and the Royal Military College joined with professional men recently for the first extension meeting in Kingston, Ont. Sponsored by the Ottawa Section of I.E.S., the meeting was held at Queens University.

Speaker of the evening was Ronald W. Selater, of J. A. Wilson Lighting & Display Ltd., who discussed "Building the Visual Environment." Jim Rylance was chairman for the meeting, and Ottawa Section Chairman Ray Thornton thanked the speaker, and spoke on behalf of the Society.

CLI Activities Include Office Lighting Clinic

Planned for office managers, building managers, architects, designers, decorators and lighting engineers, an Integrated Office Lighting Clinic was held March 20 at the Chicago Lighting Institute. The clinic was co-sponsored by the Institute and the Chicago Section of I.E.S.

Program and speakers were:

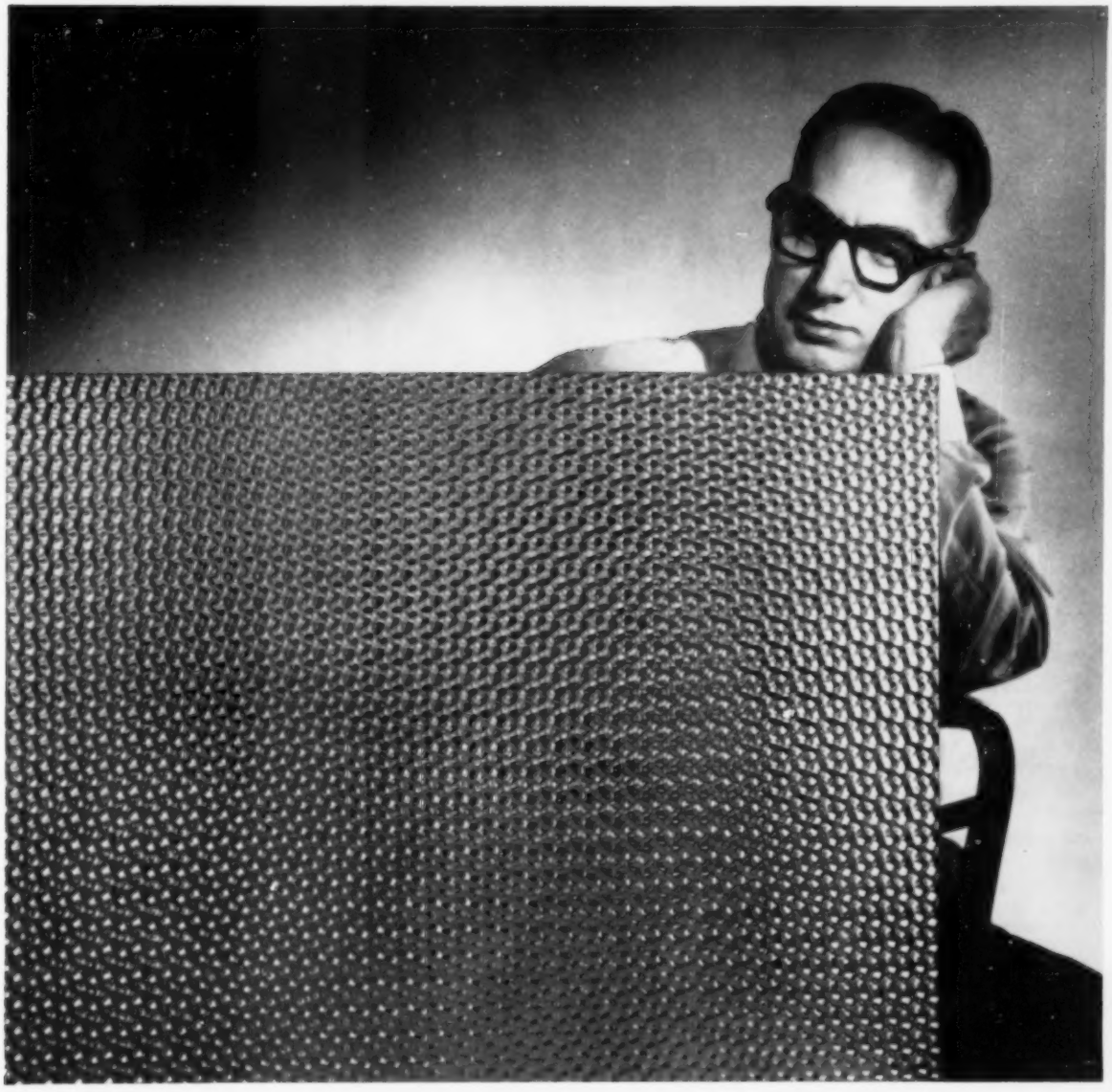
Morning Session

Chairman — J. R. Crowley, President, Office Management Association of Chicago.
The Anatomy of Vision — George Chapin. Dis-

(Continued on page 19A)

Council Meetings — 1958

Members of I.E.S. are invited to attend any meetings of the Council as guests, or to submit a communication for consideration on any matter through their Regional Vice-President or the General Secretary. Meetings of Council are scheduled for April 30, in Kansas City, Mo., and June 4-5 in New York City.



NEW FROM CORNING Crystopal Pattern No. 71

Here's a really *new* idea in glass lighting ware. It's a *single* panel that gives you brightness control plus diffusion.

Called Crystopal Pattern No. 71, it's the *first* glass panel to *combine* the advantages of both crystal and opal.

The crystal prisms provide a high level of illumination but *lower* brightness in the critical glare zones.

The partial opal reduces reflected glare, and tends to blend various hues from the lamps into a single, pleasantly *warm* tone.

You'll find these panels attractive, too. The pentagonal-prismed surface provides a new, decorative texture.

You can get new Crystopal Pattern No. 71 in flat *or* concave form for incandescent and fluorescent application, in panels up to 34x100 inches.

Put new Crystopal Pattern No. 71 to work in troffers, ceiling and shadow mounted fixtures. Use it wherever you want prismatic control with warm, uniform illumination.

Get complete specifications by writing to:

Corning means research in Glass

CORNING GLASS WORKS, 61-4 Crystal Street, Corning, N.Y.

Guth brascolite gives you Προ-πρᾶξις* in EVERY incandescent fixture!

EVERY
Brascolite Fixture has a
BRIGHTNESS CHART
COEFFICIENTS OF UTILIZATION
LIGHT CURVE
for better lighting specifications

When you figure an incandescent lighting installation, you naturally want assurance that you'll get the on-the-job performance you need.

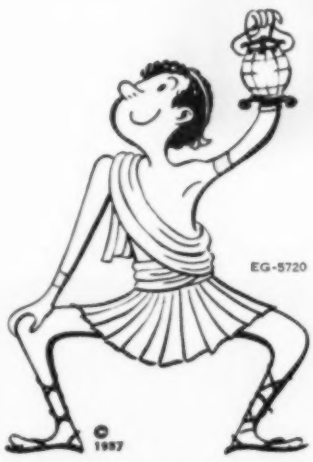
Guth gives you this assurance with PRE-FORMANCE, *predetermined* performance that means each Brascolite incandescent fixture will do the job it's supposed to.

Every Brascolite fixture, including the handsome square recessed unit shown above, has a brightness chart, coefficients of utilization and light curve, and other engineering information to help you.

And every Brascolite fixture is a carefully engineered unit, with all parts working harmoniously to produce the finest and most efficient lighting possible.

* **PRE-FORMANCE:**
Predetermined Performance
through careful engineering... takes the guesswork out of lighting calculation

FREE—*Guth Brascolite Incandescent Lighting Handbook, a complete working tool from which you can figure any incandescent lighting job. Write on your letterhead for your free copy today.*



THE EDWIN F. GUTH COMPANY ■ 2615 Washington Ave., St. Louis 3, Mo.

(*Continued from page 16A*)

trict Engineer, Large Lamp Department, General Electric Co., Chicago.

Lighting Tools — Light Sources for Office Lighting — Richard M. Smart, Regional Engineer, Sylvania Electric Products Inc., Chicago.

Lighting Systems for Offices — William Weibel, Illuminating Engineer, Curtis Lighting Inc., Chicago.

Electrical Distribution for Office Lighting — Mack Milner, Electrical Engineer, Ragnar Benson Inc., Chicago.

AFTERNOON SESSION

Chairman — James R. Sterling, Secretary, Building Managers Association of Chicago.

Integrated Office Lighting in Action — Carl W. Zersen, Managing Director, Chicago Lighting Institute, assisted by CLI staff members Kerr Sanders, Herman Sereika and Raymond Wozniak.

Integration of Lighting with Modern Architectural Practice — Bruce Graham, Assistant Chief Designer, Skidmore, Owings and Merrill.

Tour via Slides of Modern Offices — Robert M. Francis, Lighting Specialist, Benjamin Electric Mfg. Co., Joliet, Ill.

Integrating the Lighting System with a Modern Maintenance Practice — James C. Weeks, Lighting Sales Engineer, Lighting Division, Westinghouse Electric Corp.

Summary of Talks — Audience Panel Discussion and Closing Remarks.

Program Committee for the Clinic was headed by L. E. Innis, Chairman, and included Robert Allan, Ralph Lusk, Kenneth Priestap, William Weibel, Elden Witte and Carl Zersen. Registration fee was $7.50, including luncheon at the Institute's new Gallery of Light.

Other activities of the Institute currently under way are the annual Spring Quarter Courses on Lighting Fundamentals and Wiring Design No. 1. The Fundamentals course, with Raymond E. Wozniak as instructor, consists of weekly 1½-hour lecture classes April 7 through June 23, and laboratory sessions every other week from April 10 through June 19. Wiring Design No. 1 is under the direction of Frank R. McShane and consists of 2-hour classes, weekly, from April 1 through June 17. Tuition for both courses is $25.

Local Chapters Planned for Live Better Electrically Program

Plans to organize local lighting chapters to promote the Live Better Electrically's Medallion Home program and help develop an Academy of Lighting Arts have been announced by the American Home Lighting Institute. Details were made known at the February 4 residential lighting conference sponsored by the institute at Nela Park, Cleveland.

An organization guidebook has been prepared by AHLI, telling local groups how to organize and tie in with the Medallion Homes and the Academy of Lighting Arts. Copies are available, for 25 cents each, from the American Home Lighting Institute, 360 North Michigan Ave., Chicago 1, Ill.

CHARTER Night at the Forest City Chapter. At the head table are, left to right: Bob Lindsay, Toronto Section; M. B. Hastings, Member Emeritus and Past Regional V-P; V. A. McKillop, Past President, Engineering Institute of Canada; I.E.S. President Kirk M. Reid; Chapter Chairman Ernie Smith.

Charter Night Is Gala Affair For Forest City Chapter

A large and enthusiastic group attended the Charter ceremonies of the new Forest City Chapter of I.E.S., in London, Ont. on February 20. Distinguished guests, presents from other Sections and Chapters in the Region, television and press coverage were "extra" features, in addition to the customary presentation of the charter and installation of officers.

I.E.S. President Kirk M. Reid; the Mayor of the City of London, J. Allan Johnston; V. A. McKillop, Past President of the Engineering Institute of Canada; Carl Wilson and Milton Hastings, current and past Vice-Presidents of the Canadian Region, were among the many guests to bring best wishes. The Chapter's Charter was presented to Chairman Ernie Smith by Mr. Wilson, and President Reid did the honors with the gavel.

The gavel was the gift of the Coastal Bend Chapter of I.E.S., in Corpus Christi, and was made by one of the charter members of the Texas group. It is of teakwood and mahogany, and has an inscription on a gold plaque in the shape of the State of Texas on the head.

Other gifts, to get the Chapter going,

(*Continued on page 20A*)

PRESENTATION of Charter and Gavel to Forest City Chapter Chairman Ernie Smith (at right in both photos). Canadian Regional V-P Carl Wilson presents the charter in photo at left, and President Kirk Reid presents the gavel in photo at right.

(Continued from page 19A)

were presented by some other Sections and Chapters in the Region. These are: Record File, Toronto Section; Ledger, Hamilton Chapter; Cash Book, Ottawa Section; and Attendance Record, Montreal Section.

14th Annual Wiring Conference

Nearly 300 wiring promotion executives and industry leaders met in Detroit February 20 and 21 for the National Wiring Bureau's Fourteenth Annual Conference. The program included talks by electrical industry leaders, reports on local promotion of residential and commercial wiring, a panel discussion of the Medallion Home program and the presentation of the fourth annual *Look* magazine awards. Complete sets of the conference speeches are available, at no charge, from the Bureau, 155 East 44th St., New York 17, N. Y.

ATTENDANCE was 225 at the joint Michigan-Northwestern Ohio Section meeting, February 11.

Highway Lighting Institute Held for Public Officials

A total of 79 representatives from the U. S. Bureau of Public Roads, 30 states, the District of Columbia and Puerto Rico attended the two three-day sessions of a Highway Lighting Institute conducted in February by General Electric Co. Outdoor Lighting Department in Hendersonville, N. C. The conference was designed to familiarize members of state highway departments and the BPR with highway lighting systems and modern design concepts that can be used to provide maximum night-time safety on the 41,000-mile federal highway network.

Delegates received an indoctrination in basic highway lighting system design and application and participated in workshop sessions devoted to the design of typical lighting systems for intersections, cloverleafs, tunnels and underpasses, bridges and viaducts, heavily-traveled urban highways, guide signs and access roads.

Office Lighting Featured In Two-Part Joint Meeting

A tour of the new general offices of the Ford Motor Co. in Dearborn, Mich., and a discussion of the problems in lighting them was one highlight of the joint meeting of the Michigan Section and the Northwestern Ohio Section of I.E.S. on February 11. A technical session and a dinner were also on the program which attracted 225.

The meeting began at 4:30 with a technical session, when Professor Walter Hedrich, University of Michigan, spoke on the Fundamentals of Lighting. Following this was dinner, and then the tour of the Ford offices, with architects' representatives Carl Russell, Jr., of Welton Becket Associates, and Sol King of Albert Kahn, as guides. Mr. Russell and Mr. Kahn then discussed the problems and solutions in lighting the offices.

Of special interest at the dinner was the presentation to N. Atakkaan, a student at the University of Michigan, of a copy of the *I.E.S. Lighting Handbook*, honoring him for his outstanding work in lighting design.

Credit for arranging the highly successful meeting goes to Byron H. Becker,

(Continued on page 22A)

AT THE head table are, l. to r.: John Cloer, Chairman, Northwestern Ohio Section; James F. Finn, Chairman, Michigan Section; Byron H. Becker, Program Chairman.

UNIVERSITY of Michigan student N. Atakaan is presented with an award, the *I.E.S. Lighting Handbook*, by Mr. Finn. Award was given for his work in lighting design.

THE HENRY and EDSEL FORD AUDITORIUM, Detroit.
O'Dell, Hewlett & Luckenbach Assoc. and
Crane, Kiehler & Kellogg—Architects.

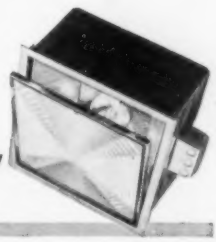
and why do they know the NAME so well?

Should you ask the many famous architects, builders and contractors why the KIRLIN name is so favorably known, they could each give you a variety of reasons—but probably three reasons would always be mentioned:

(1) KIRLIN is the most widely used built-in lighting fixture—with WIDE-ANGLE lenses that actually light the *vertical* surfaces as well as the horizontal surfaces; (2) KIRLIN can be used in many types of ceilings, for relamping from below (or from above on high ceilings); and (3) KIRLIN is the original built-in fixture of this type. Other recessed fixtures have been made to "look like Kirlin's", but none have duplicated their efficiency and effectiveness.

OTHER REASONS FOR SPECIFYING KIRLIN

- **GlasSurfaced aluminum reflectors**
- **For fluorescent or incandescent lamps**
- **Available in many types and all sizes**
- **Spread-type lens, stays clean**
- **Stainless steel hinged doors**
- **Easily installed**
- **In stock at leading electrical jobbers**
- **Underwriters Laboratory and I.B.E.W. labels**



SALES ENGINEERS IN PRINCIPAL CITIES

The KIRLIN CO. 3435 E. JEFFERSON AVE. DETROIT 7, MICHIGAN

(Continued from page 20A)

Michigan Section, Dave Kirby, Northwestern Ohio Section, and Professor Ed Fairchild, who was Chairman of the technical session.

Puget Sound Section Conducts Daylighting Studies

Availability of daylight in the Pacific Northwest has been under review since late in 1954, when the Puget Sound Section of I.E.S. began a Daylighting Study, with systematic records of illumination levels at the University of Washington during daylight hours.

The need for this study, in the Section's opinion, is illustrated by the fact that all State school lighting is governed by basic rules as established in such areas as Southern California. The Section's Daylighting Committee feels that, with the many low-brightness days during the winter months in the Pacific Northwest, the foundation for thinking on lighting sources should be indigenous to the latitude and longitude of the area.

Chairman of the original Committee was the late Professor Gordon R. Schuck of the University of Washington. Current chairman is Dr. Howard Hall, Seattle optometrist.

Residential Lighting Forums — A Vital IES Development

A few years ago, the then General Secretary, George J. Taylor, ran a series of informative items in IE, under the title "Operation IES." Details of numerous Society offices, developments and operations were discussed in these pieces, greatly to the advancement of membership knowledge. His term expired before he had covered *all* of the many phases of IES work. The following item is in response to requests for further information on one of the Society's most successful operations — Residential Lighting Forums.

There are at present eleven Forums, each sponsored by, and associated with an IES Section. Their success is extraordinary, as witness the following information on programs, attendance, educational projects, etc.

Although closely associated with its "parent" Section, and in some cases supported by the Section, each Forum is autonomous in its operation. It elects its own officers and board of managers; operates under its own by-laws or the suggested by-laws in the Forum Guide; has its own roster of members, who may or may not be members of IES. It has its own scale of dues, and conducts its own financial affairs.

Membership

Who are members, and how many are there? Leading the list of professions and industries represented in Forum membership are interior designers, architects and utility home lighting advisors and salesmen. There are a number of other interests represented, however. Portable lamp buyers and dealers, city planning and housing representatives, home department editors, to name a few. Total membership for ten of the Forums (the eleventh, Capital Section has just been organized) is 799. Of this total, 413 are so-called Affiliate members; that is, dues-paying members in good standing of the Residential Lighting Forum only, and not members of IES. Some 386 of the Forum members are also members of IES, and their additional membership in the Forum requires no dues.

Local Administration

The local IES Section is the sponsor of

(Continued on page 25A)

Residence Lighting Forum Chairmen

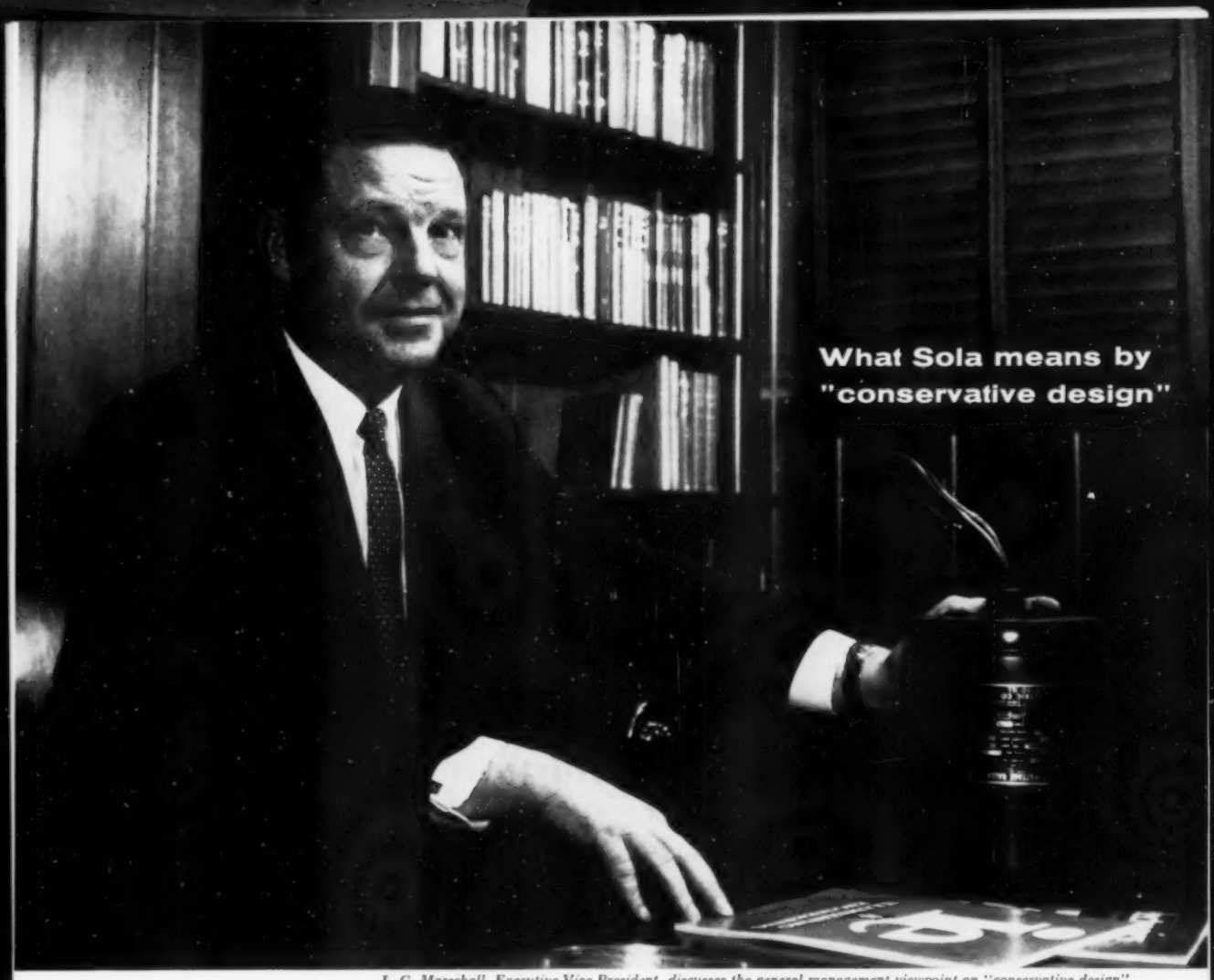
Arizona Section, William Downey (left), *Chairman*; Capital Section, Ben Goodman (right), *Chairman*.

Chicago Section, O. J. Scodock (left), *Chairman*; Georgia Section, Rita Kuzell (right), *Chairman*.

Michigan Section, Lloyd Gabler (left), *Chairman*; New York Section, Marion Seitz (right), *Chairman*.

North Texas Section, Clarence Cockrell (left), *Chairman*; St. Louis Section, Benjamin Duhov (right), *Chairman*.

Tennessee Valley Section, Elizabeth O'Kelley (left), *Chairman*; Twin City Section, Richard Graf (center), *Chairman*; Utah Section, J. Vernon Sharp (right), *Chairman*.



L. C. Marschall, Executive Vice President, discusses the general management viewpoint on "conservative design"

"What we claim for Sola Mercury Lamp Ballasts they will do . . . and then some"

It's usually quite difficult to find a comfortable position seated out on a limb. We, at Sola, avoid this unenviable position by making sure our mercury lamp transformers perform as we claim they will, plus an adequate margin of safety.

Any Sola Mercury Lamp Transformer will consistently exceed the product claims of operation we make for it. There is no doubt that we could make stronger statements and still be within the limits of the transformers' capabilities. We prefer, however, to keep our claims conservative and straightforward. This is in keeping with our policy of conservative design which is prevalent throughout Sola's entire line of products.

For example, we state that our ballast for one 400-watt mercury lamp has an efficiency of 89.2 percent. This is conservative. If anyone claims higher efficiency than this, we prefer it be you — after you've had experience with the operation of this constant wattage mercury lamp transformer.

Write for your copy of Bulletin 3D-MV-306

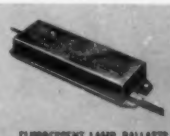
Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill., Bishop 2-1414 • Offices in principal cities • In Canada, Sola Electric (Canada) Ltd., Canmotor Ave., Toronto 14, Ont.

SOLA

CONSTANT VOLTAGE TRANSFORMERS

REGULATED DC POWER SUPPLIES

MERCURY LAMP TRANSFORMERS


FLUORESCENT LAMP BALLASTS

48-250 open reflector downlight uses inexpensive general service type lamps up to 300 watts. Most often specified for department stores, banks and public lobbies.

Chemical Corn Exchange Bank, New York

48-500 high ceiling ellipsoidal open reflector downlight for auditoriums, churches, museums. Available with Alzak natural or golden reflector in 300, 500, 750 and 1,000 watt sizes.

48-1220 for gymnasiums and lunchrooms, playrooms and arenas. Spoke guard is of solid cast aluminum, heat-treated for strength. Available for surface, recessed, pendant or I-beam installations. Wattages up to 1,000 . . . also in mercury vapor series.

This photographic report taken by the Committee on Lighting of the Central Station Properties, Illuminating Engineering Society in October 1954 visually proves the importance of properly ventilated lamp husks.

Dirty	Improvement	Cleanest
No. 1 Test	No. 2 Test	No. 3 Test
No vents	Vents poorly located	Vents properly located

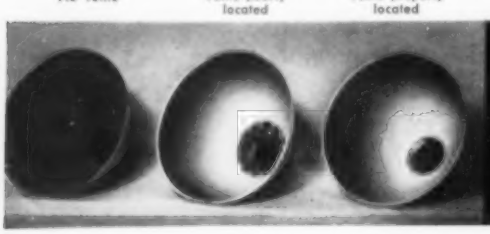
downlights by mc Philben

cooler burning
lower maintenance costs
tested and proved

mcPhilben's 48 series interior downlights were selected to light the main area of the Chemical Corn Exchange Bank in New York in 1957. Today, after more than a year of operation, maintenance engineers report an operating efficiency and lamplife unequalled by any other downlight in use.

All mcPhilben interior downlight units are equipped with cast aluminum radiators and cooling fins. This outstanding engineering feature assures cooler burning and longer lamplife. In addition, reflectors remain cleaner and brighter for longer . . . as proved in the I.E.S. test shown below.

Full details on these downlights are now available on individual specification data sheets. Ask your mcPhilben representative for your copies or write to mcPhilben. Ask for the 48 and 84 lines.



mc Philben
LIGHTING COMPANY
1329 WILLOUGHBY AVENUE, BROOKLYN 37, NEW YORK

(*Continued from page 22A*)

each Forum, although its participation in Forum affairs varies, depending upon how independent and self-sufficient the individual group may be. Newer and smaller Forums may depend entirely on the Section for support and guidance. Either way, however, the affairs of the Forum are administered by an Executive Committee elected by the Forum membership. Usually this consists of a Chairman, perhaps a Vice-Chairman also, a Secretary and/or Treasurer and must have also at least two members-at-large. The Chairman, and at least one other member, must be a member (in any grade) of the Illuminating Engineering Society. The Chairman of the Forum also attends all Board of Managers meetings of the parent Section, as a non-voting coordinator. As with Section and Chapter operation, the Forum Chairman appoints committees to carry out the working affairs — Program, Membership, etc.

National Organization

On a national level, the Forums are under the aegis of the national Residence Lighting Forums Committee. Current chairman of this committee is Miss Virginia Skinner, Long Island Lighting Co., Old Country Road, Mineola, L. I., N. Y. This committee coordinates the whole program of Residence Lighting Forums in general, plans for a RLF session at the National Technical Conference and arranges for its speakers, and reports to Council on Forum activities. This committee, which meets regularly to discuss current and future planning, works to develop additional Forum groups throughout the country. It has prepared a Guide for Forum Operations, and Sections or Chapters interested in developing a Residence Lighting Forum may write to Miss Skinner for a copy, and for further information and encouragement.

Programs and Projects

Real leadership in the residential lighting field has resulted from the Forum programs. Here is an IES group which is definitely not "talking to itself." Countless decorators, home-makers and others have been educated in lighting techniques through Forum programs; the principles and application of good lighting practice have been brought before hundreds of users and specifiers of lighting. This group of IES members and affiliates have in the highest sense "disseminated information and knowledge in the practice and principles . . . "

Even the statistics are impressive. During 1956-1957, for example, the ten Forums then operating held a total of 49 meetings, with a total attendance of 2,735. To the middle of February this year, the attendance is 1,559 with the average per meeting well over 60. And still, this is exclusive of the many special projects conducted in addition to these regular program meetings.

A list of all of these special projects would be too long. Typical examples:

Regular 6 to 10 session courses in residential lighting aimed at decorators, architects and home-makers.

Work-shops — educational programs, full-day schedules, sometimes a full week of meetings, with top speakers from the home lighting field.

A Residential Lighting Fixture Fair. This was in Minneapolis, and featured new trends, new equipment and applications.

Lighting design competitions. Several of these, conducted for vocational high school students, as an example.

Inspection tours of outstanding installations; panel discussions of lighting trends.

One Forum sponsors a permanent garden lighting display in cooperation with the local Garden Club. The Dallas group has scheduled a box-lunch picnic meeting in a lighted garden next June.

All of the Forums sponsor entries in Class I of the MMILJ contest.

It can be seen that this branch of IES most successfully fulfills its aim. As out-

(*Continued on page 26A*)

SCHEDULED EVENTS

April 20-26, 1958 — Society of Motion Picture and Television Engineers, Ambassador Hotel, Los Angeles, Calif.

April 21-23, 1958 — Building Research Institute (Seventh Annual Meeting), Shoreham Hotel, Washington, D. C.

April 24-25, 1958—South Central and Southeastern Regional Conference, Lafayette Hotel, Little Rock, Ark.

April 28-29, 1958 — Southwestern Regional Conference, Hotel Washington Youree, Shreveport, La.

April 28-30, 1958 — National Association of Lighting Maintenance Contractors (Annual Convention), Statler Hotel, Cleveland, Ohio.

April 30, 1958 — Council Meeting, I.E.S., Hotel President, Kansas City, Mo. Members are free to attend meetings of Council as guests.

May 1-2, 1958 — Midwestern Regional Conference, Hotel President, Kansas City, Mo.

May 8-9, 1958 — Inter-Mountain Regional Conference, Whitman Hotel, Pueblo, Colo.

May 12-13, 1958 — South Pacific Coast Regional Conference, El Cortez Hotel, San Diego, Calif.

May 22-24, 1958 — Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Oregon.

June 4-5, 1958 — Council Meeting, I.E.S., New York, N. Y. Members are free to attend meetings of Council as guests.

June 9-13, 1958 — National Association of Electrical Distributors, 50th Annual Convention, Civic Auditorium, San Francisco, Calif.

June 23-24, 1958 — Great Lakes Regional Conference, Sheraton Hotel, Rochester, N. Y.

June 23-27, 1958 — American Institute of Electrical Engineers (Summer General Meeting), Buffalo, N. Y.

August 17-22, 1958 — Illuminating Engineering Society (National Technical Conference), Royal York Hotel, Toronto, Canada.

August 19-22, 1958 — American Institute of Electrical Engineers, Pacific General Meeting, Sacramento, Calif.

September 22-25, 1958 — Institute of Traffic Engineers (Annual Meeting), McAllister & Columbus Hotels, Miami, Florida.

October 8-10, 1958 — Canadian Electrical Manufacturers Association (14th Annual Meeting), Sheraton Brock Hotel, Niagara Falls, Canada.

October 10-11, 1958 — International Association of Electrical Inspectors (Canadian Section), Toronto, Ont.

October 13-14, 1958 — U. S. National Committee of the International Commission on Illumination (C.I.E.), Annual Meeting, Nittany Lion Inn, State College, Pa.

October 13-15, 1958 — National Electronics Conference, Inc., Hotel Sherman, Chicago, Ill.

October 19-24, 1958 — Society of Motion Picture and Television Engineers, Sheraton-Cadillac Hotel, Detroit, Mich.

October 20-24, 1958 — National Safety Council (46th National Safety Congress & Exposition), Chicago, Ill.

October 27-31, 1958 — American Institute of Electrical Engineers (Fall General Meeting), Pittsburgh, Pa.

November 10-14, 1958 — National Electrical Manufacturers Association (Annual Meeting), Traymore Hotel, Atlantic City, N. J.

November 18-20, 1958 — American Standards Association (9th Annual Conference on Standards), Hotel Roosevelt, New York, N. Y.

January 19-23, 1959 — American Institute of Electrical Engineers (Winter General Meeting), New York, N. Y.

March 1-4, 1959 — National Electric Sign Association, Morrison Hotel, Chicago, Ill.

March 30 - April 1, 1959 — Chicago Electrical Industry Show, Hotel Sherman, Chicago, Ill.

(Continued from page 25A)

lined in its Guide, this is:

1. To encourage an interest in the Society's work and ideals on the part of those increasing numbers of men and women who are seriously engaged in the residential fields and who should be members of the Society.
2. To promote the application of illuminating engineering principles by a much larger group whose interest, for the present at least, is completely commercial and who offer very limited possibility of membership in the Society.
3. To broaden and strengthen mutually the Society's and the industry's contribution to residence lighting advancement through organized activity.

ABOUT PEOPLE

Union Metal Manufacturing Co., Canton, Ohio has announced the appointment of **L. F. Heckmann** as general sales manager to succeed **D. B. Hanna,** former vice-president in charge of sales, who retired on February 28. Mr. Heckmann, who joined the company in 1937 was named manager of the Street Lighting Sales Division in 1944 and assistant general sales manager in 1950. He is Secretary of the IES Roadway Lighting Committee, and is also active in NEMA, where he is serving as Chairman of the Technical Committee on Street Lighting.

Charles R. Pritchard, a vice-president of General Electric Co., and former manager of the General Electric Supply Co., has been appointed special consultant to that division. Replacing him as head of the Supply Co. is **William C. Wichman,** also a vice-president, and formerly general manager of the soon-to-be-discontinued Industrial Power Components Division. Mr. Wichman will make his headquarters in Bridgeport, Conn.

Sylvania Lighting Products, a division of Sylvania Electric Products, Inc., has announced the appointment of **James R. Steel** as advertising manager. Mr. Steel, who joined the Argus Camera Division of Sylvania in 1946, was most recently advertising manager of that department. In the Photolamp Department of Sylvania, **John S. Williams** has been named merchandising manager and **Edward L. Slater,** advertising manager. Mr. Williams succeeds **Henry W. Jones** who is photolamp sales manager — national accounts.

F. S. Huot has been elected president of Kopp Glass, Inc., succeeding **C. J. Huot** who becomes chairman of the board. F. S. Huot has been executive vice-president of the company since 1946, and prior to that was production manager.

Globe Lighting Products, Brooklyn, N. Y. has named **Lou Goren** manager of architectural sales engineering. Mr. Goren, a past chairman of the New York Section of IES, has been associated with General Electric Co., Cathode Tube Corp., and Smitheraft Lighting. **Morton Eisenberg** was appointed resident sales manager at Globe.

At a recent meeting of the Board of Directors of Pittsburgh Reflector of Canade, Ltd., Toronto, the following executive appointments were announced. **Lynn**

(Continued on page 28A)

1958 Regional Conferences, I.E.S.

Region	Place	Date
South Central and Southeastern	Lafayette Hotel Little Rock, Arkansas	April 24-25
Southwestern	Washington Youree Shreveport, La.	April 28-29
Midwestern	Hotel President Kansas City, Mo	May 1-2
Inter-Mountain	Whitman Hotel Pueblo, Colo.	May 8-9
South Pacific Coast	El Cortez Hotel San Diego, Calif.	May 12-13
Pacific Northwest	Multnomah Hotel Portland, Oregon	May 22-24
Great Lakes	Sheraton Hotel Rochester, N. Y.	June 23-24

leaves from the...

HISTORICAL COMMITTEE'S SCRAPBOOK

Historic Lighting Advice

From the "New Leslie's Homebook," published in Philadelphia in 1840 come these recommendations:

"Choose the shades of plain ground glass, as they give the clearest steady light, and are best for the eyes. The fashion of having shades . . . decorated with flowers, or clear spots cut on glass is on the decline."

"To buy table astral (whale-oil?) lamps of inferior size, is by no means advisable. They only give light in proportion to their magnitude, and when they are small and low, the effort of seeing by them is so teasing to the optic nerve that the eyes seldom fail to become weak."

In 1847, Catherine E. Beecher, sister of Harriet Beecher Stowe, famous author of "Uncle Tom's Cabin," in her "Treatise of Domestic Economy" urged this:

"Weak eyes should always be shaded from the lights. Small screens made for the purpose should be kept at hand. Provide small, one-wicked lamps to carry about, and broad-bottomed lamps for the kitchen, not easily upset. Cheap lights are made by dipping rushes in tallow."

Finally, in 1869, Harriet Beecher Stowe emphasized:

"In choosing the source of our light, the great points to be considered are, first, the influence on the eyes, and second, economy. It is poor economy to use bad light."

"Modern houses in cities, and even in large villages are furnished with gas. Where gas is not used, sperm oil, kerosene or coal-oil, and candles are employed. Gas is cheapest, or ought to be. Good sperm oil burned in an Argand Lamp . . . is perfect!"

Integrated ceilings were used to revitalize the interiors. Wm. G. Merchant, Architect; Smith and Garthorne, Consulting Electrical Engineers; Chas. B. Farrow, Inc., Electrical Contractor. All in San Francisco.

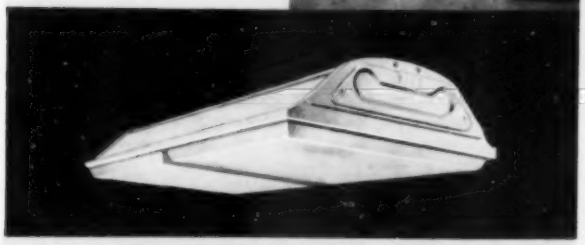
HOW TO MAKE NEW BUILDINGS FROM OLD...

Pacific Gas & Electric Company did it with integrated ceilings featuring 3700 ALL-BRITE MODU/LITERS

EASY!

Formula for a magic transformation: take an old building with high ceilings, suspend new ceilings on T-bar frames with all heat and air ducts above, rest All-Brite Modu/Liters on same T-bars, remodel below. Voila! — a new interior, bathed in 100 foot candles of evenly distributed fluorescent light. Wm. G. Merchant, with Smith and Garthorne, did it for P. G. & E. in San Francisco . . . you can do it, too! Ask us for the full story.

All-Brite
LIGHT OF THE WEST



All-Brite Modu/Liter is made in 2 x 4 foot modules, for 2, 3 or 4 rapid start lamps. Fixtures rest on T-bars supporting new ceiling. All ductwork is above.

FLUORESCENT FIXTURES OF CALIFORNIA

352 SHAW ROAD
SOUTH SAN FRANCISCO, CALIF.

PLANTS ALSO IN LOS ANGELES; PORTLAND, OREGON; AND VANCOUVER, B. C., CANADA

(Continued from page 26A)

W. Ferguson was made a vice-president of the company and **John R. Clitherow,** general manager. Mr. Ferguson has been associated with Pittsburgh Reflector in the United States for the past ten years and prior to that headed the Wheeler Reflector Co. in Canada. Mr. Clitherow was formerly executive vice-president and general manager of the Mitchell Manufacturing Co. of Canada.

Ebasco Services, Inc. has announced that **T. E. Flowers, Jr.** and **R. F. Hay** have joined the staff of its Space Planning Department. Before joining Ebasco, Mr. Flowers was a senior associate management consultant with Bruce, Payne and Associates. Prior to that, as a staff member of Louis J. Kroeger and Associates, he acted as an organization and management consultant to the Philippine government. Mr. Hay was formerly vice-president of the Division of Relocation Studies for Todd and Draper Corp.

George T. Wood has been signed by Smitheraft Lighting, Chelsea, Mass. as manager of lighting sales. Mr. Wood comes to Smitheraft from the Lewyt Corp., where he was Mid-West and South-East sales manager. **Herbert Nock** continues as Western and Southern Divisional sales manager, and **Charles A. McKenna** as Eastern Divisional sales manager.

The Photolamp Department of the Westinghouse Lamp Division has announced the appointment of **Willett R. Wilson** as original equipment sales manager. In this newly created position, Mr. Wilson will be responsible for sales and marketing with the original equipment manufacturers. His offices will be at the Lamp Division headquarters in Bloomfield, N. J.

Robert L. Bouse has been promoted to general sales manager of Waljohn Plastics, Inc., Brooklyn, N. Y. and its two divisions, Rotuba Extruders, Inc. and Maridson Manufacturing Co. Waljohn has also announced several appointments in the sales field. **David Friedwald** will help supplement sales in the metropolitan New York area, **O'Connell & Associates** will cover the Chicago territory, and **Jannell Plastic Sales** will be sales representative in the Cleveland area.

Appointment of **Zeb Chaney** as Southern sales manager has been announced by the Prescolite Manufacturing Co. Mr. Chaney was formerly sales manager for the Gowers Container Corp., Jacksonville, Fla. The new Prescolite plant at El Dorado, Ark., where he will make his headquarters, is expected to be in operation by April 1. The company also maintains plants at Berkeley, Calif., and Neshaminy, Pa.

R. A. Manning Co., Inc., Sheboygan, Wis., manufacturers of lighting equipment for churches and institutional buildings, has announced the signing of **Chassaing Brothers** — Lighting as their St. Louis agents. Chassaing Brothers also represent the Art Metal Co. and Sunbeam Lighting Co.

Jules Levenstein has been appointed New York district sales manager by Silvray Lighting, Inc., Bound Brook, N. J. and New York City. Also announced was the appointment of **Sheldon Golden** as architectural contract representative. **E. S. Bruce,** long associated with Silvray, will continue to operate out of the company's New York office.

Lighting Products Inc., Highland Park, Ill. has announced several personnel changes. New officers and men in charge of various operations are as follows: **H. A. Glass,** executive vice-president; **R. M. Lacy,** controller; **P. V. Hoppel,** purchasing agent; **E. H. Church,** vice-president in charge of sales and operations; **E. F. Kiehl,** sales service manager; **E. Iversen,** factory manager; **M. E. McCreight,** design engineer; **D. W. Davis,** research and development engineer.

Clyde Dodd has been appointed to the staff of Donald S. Gleason and Associates, Seattle, representatives for the Prescolite Manufacturing Co. in Washington and Oregon. Mr. Dodd will cover the Oregon territory.

Appointment of **E. W. Michel** as assistant manager of interior lighting sales for the Westinghouse Electric Corp. Lighting Division in Cleveland has been announced. Mr. Michel has been with Westinghouse since 1948 and was a lighting sales engineer prior to this appointment.

Tyre Bros. Glass Co. has been named Pacific Coast distributor for Corning Fluorescent Lighting Glassware by the Corning Glass Works. The company is also distributor for Libbey-Owens-Ford glass products.

D & F Sales Co., Inc., Boston has been appointed sales representative for Markel Electric Products, Inc. and LaSalle Products, Inc., both of Buffalo, N. Y. Their sales territory will include all of New England with the exception of New Haven and Fairfield Counties in Connecticut. **Schooler-Gorman Co.,** Kansas City, Mo. will represent Markel and LaSalle in Kansas and Missouri.

Harry H. Wenk of Beverly Hills, Calif. has been signed as West Coast representative for the Merix Chemical Corp. of Chicago.

Leonard W. Towner of Pasadena, Calif. retired on March 1 after more than 29 years with the General Electric Co. At the time of his retirement, Mr. Towner was Lighting Specialist in the company's Pacific Southwest District in Los Angeles.

The Frink Corp. has signed **Robert D. Sweeney** Associates, Grosse Ile, Mich. as their sales representatives throughout the state. Associated with Mr. Sweeney in the firm is **Les Meidamos** of Ann Arbor.

Deaths

Joseph J. Anastasi, New England Section
Edward E. Ashley, Jr., New York Section
H. F. Meyers, Cleveland Section
Peter M. Pavesich, Chicago Section

NEW MEMBERS

At the recommendation of the Board of Examiners of I.E.S. on March 13, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade.

ALABAMA SECTION

Associate Member:

Fuller, D. H., General Electric Co., Birmingham, Ala.

ALAMO SECTION

Associate Member:

Milam, T. A., 138 Marcia Place, San Antonio, Texas.

ARIZONA SECTION

Member:

*Eaton, E. A., Arizona Public Service Co., Yuma, Ariz.

Associate Member:

Martin, J. S., Arizona Public Service Co., Phoenix, Ariz.

ARK-LA-TEX CHAPTER

Associate Member:

Hampton, G. T., Graybar Electric Co., Inc., Shreveport, La.

BRITISH COLUMBIA SECTION

Member:

Ryan, L. E., City of Vancouver, Vancouver, B. C.

Associate Members:

Holland, D. E., M. A. Thomas, Vancouver, B. C.
Jackson, W. H., McLaren Electric Ltd., Vancouver, B. C.
Krawchuk, P., Dominion Sound Equipments Ltd., Vancouver, B. C.
MacDonald, J. G., Provincial Government, Vancouver, B. C.

(Continued on page 54A)

GENERAL ELECTRIC'S 20th FLUORESCENT ANNIVERSARY ANNOUNCEMENT:

R. N. THAYER (left) AND G. E. INMAN developed first commercial fluorescent lamp in the U.S.A. in 1938. Still with General Electric, they have been key men in many G-E fluorescent lamp improvements.

Today's G-E Fluorescent Lamps give your customers 76% more light per watt, last 5 times longer...yet cost 1/2 as much!

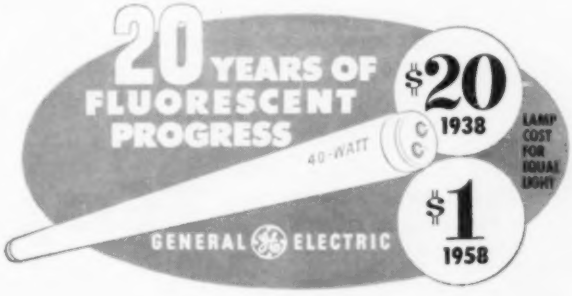
The first fluorescent, introduced 20 years ago this month by General Electric, can't hold a candle to today's G-E 40-watt Lamps. A steady stream of improvements from G.E. in Rapid Start and Pre-Heat Lamps has provided up-to-the-minute lighting systems for G-E Lamp users. Efficiency is up 76%, rated life is 5 times longer, and the list price is down 57%. *This means one G-E Fluorescent Lamp dollar today buys as much light as $20 did 20 years ago!*

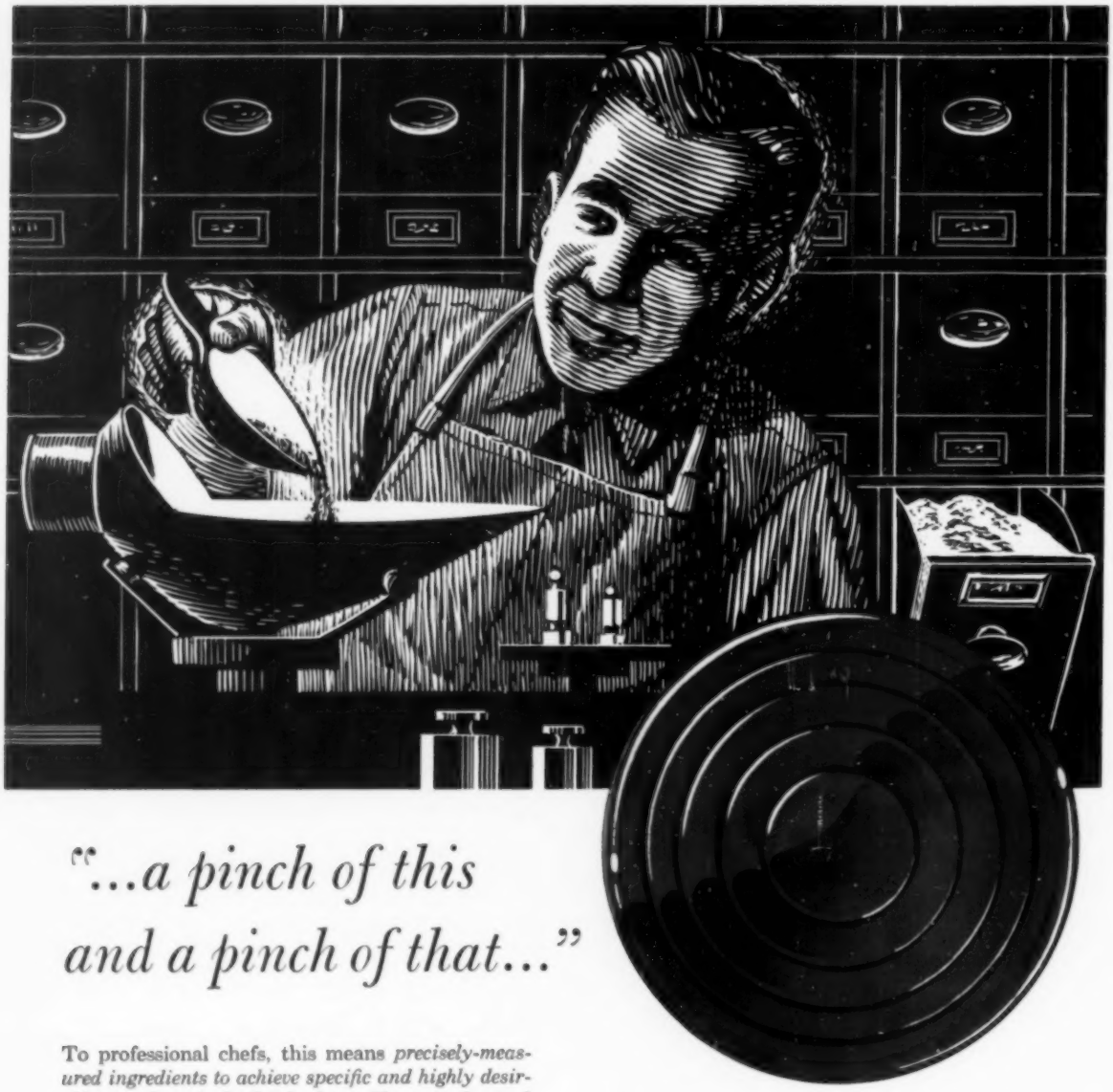
NEWEST IMPROVEMENT—"BONUS PHOSPHOR". This revolutionary new G-E process gives your customers 7 to 9% more light by selecting only the bigger, brighter phosphors to be used in G-E Lamps. It is another dollar-and-cents reason why they get more for all their lighting costs with General Electric Lamps.

Progress Is Our Most Important Product

GENERAL ELECTRIC

This "Bonus Phosphor" is now available in the 40-watt and new Power-Groove—and will soon be used in all G-E fluorescent lamp types. For the whole "Bonus Phosphor" story—see or write your local G-E Large Lamp Salesman or write: General Electric Co., Large Lamp Dept. IE-48, Nela Park, Cleveland 12, Ohio.





"...a pinch of this and a pinch of that..."

To professional chefs, this means *precisely-measured ingredients to achieve specific and highly desirable results.* And that's how Kopp-engineered glass lenses and color filters are made.

A user requires a glass with specific color . . . mechanical strength . . . light transmission . . . thermal shock resistance . . . or other properties. Kopp engineers analyze these requirements and develop a "recipe" (or batch formula) to meet them, properly proportioning and mixing carefully-measured ingredients—various fluxes, stabilizers, and other materials.

This mix is melted under accurately-controlled temperatures and the molten glass is pressed to exact dimensions in Kopp-engineered molds. Subsequent cooling, annealing, grinding and finishing operations—all under strict quality control—result in a product which meets the user's specifications *exactly.*

Kopp engineers have produced more than 1000 different types of specialized glass in this manner. We offer you a highly-perfected engineering and manufacturing service for parts required in relatively small production runs. Call or write us at your convenience.

KOPP GLASS SPECIALISTS IN TECHNICAL GLASS

Kopp Glass INC.

SWISSVALE, PENNSYLVANIA

COMMITTEE PERSONNEL

COMMITTEES 1957-1958

All committees are appointed by the President, subject to approval of the Council. Except as provided in the Constitution, appointments terminate at the time of the first Council meeting of the following administration. The scope of each committee is indicated.

K. M. Reid, President, ex-officio member of all Standing, General and Task Committees.

G. J. Taylor, Vice-President, ex-officio member of all Technical Committees.

STANDING COMMITTEES

COUNCIL EXECUTIVE — To conduct the affairs of the Society between Council meetings.

K. M. Reid, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

J. B. Browder — R. G. Slauer
J. R. Chambers — G. J. Taylor

BOARD OF FELLOWS — To evaluate the eligibility of candidates for transfer to grade of Fellow according to procedures approved by Council.

George E. Shoemaker, Chairman, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia 5, Pa.

Willard Allphin — J. S. Hamel
Leland H. Brown — Roy A. Palmer
Edward Rambusch

FINANCE — To have direct supervision of the financial affairs of the Society and to present to the Council an annual report on its financial condition. To make recommendations to the Council as to the investment of moneys and upon all specific appropriations. To prepare and submit for approval of Council not later than the first new Council meeting a budget of income and expense for the ensuing fiscal year.

W. P. Lowell, Jr., Chairman, Sylvania Electric Products Inc., Salem, Mass.

A. C. Barr — C. C. Keller
J. R. Chambers, ex-officio — R. M. Zabel

GENERAL BOARD OF EXAMINERS — To investigate the qualifications of all applicants for admission to membership; to elect or reject applicants for the grade of Associate Member and Student Member, to report such action to the Council; and to make recommendation to the Council regarding applications for transfer or election to the grade of Member or Retired member, and for transfer to the grade of Member Emeritus.

Ralph H. MacVean, Chairman, Consolidated Edison — Westchester, 9 So. 1st Ave., Mt. Vernon, N. Y.

Svend W. Bruun — H. E. D'Andrade

MEDAL AWARD — To evaluate the eligibility of candidates for award of the I.E.S. Medal according to procedures approved by the Council.

L. E. Tayler, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Julius Daniels — H. H. Magdsick
R. F. Hartenstein — Hoyt P. Steele
B. J. Jensen — M. N. Waterman
D. M. Jones — J. F. Whitehead

PAPERS — To procure, review and approve all technical papers and discussions thereof, for presentation before National Conferences of the Society.

H. F. Davidson, Chairman, Curtis Lighting of Canada, Ltd., 195 Wicksteed Ave., Leaside, Toronto, Ont.

Floyd W. Sell, Vice-Chairman, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

L. E. Barbrow — Kurt Franck
B. S. Benson — O. B. Goldsmith
R. L. Biesele, Jr. — S. K. Guth
F. C. Breckenridge — Ted Sargent
James Cox — G. A. Trosper
George Wakefield

PUBLICATIONS — To be responsible for the procurement, review and approval of all material for the publications of the Society other than technical papers approved by the Papers Committee for presentation at National Conferences of the Society and their discussions and committee reports, for which it will have publication responsibility only. Shall also be responsible for the editing, printing and business management of the publications of the Society; specific exceptions may be made by Council.

R. M. Zabel, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Brooks Chassaing — H. F. Davidson
J. R. Chambers — R. W. Morris
J. S. Schuchert

Technical Content

H. F. Davidson, Chairman, Curtis Lighting of Canada Ltd., 195 Wicksteed Ave., Leaside, Toronto 17, Ont.

L. E. Barbrow — O. B. Goldsmith
B. S. Benson — S. K. Guth
R. L. Biesele, Jr. — Ted Sargent
F. C. Breckenridge — Floyd W. Sell
Kurt Franck — G. A. Trosper
George Wakefield

Editorial Content and Technical Data Sheets

R. W. Morris, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

G. J. Anderson, Jr. — Michael N. Flynn
L. T. Johnson

Home Lighting Data Sheets

Eve Freyer, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

REVIEWING SUBCOMMITTEE

Lillian Eddy — Katherine Goodall
Jan Reynolds

CONTRIBUTING SUBCOMMITTEE

Nelson Bleisch — Aileen M. Page
Carolyn J. Epperson — Ruth Patterson
Stella Fetzer — Margaret Summers
Melrose Franklin — Mary Taepke
J. B. Hacker — Dorothea Underwood
Dorothy McGregor — Blanche Waggener

Publication Sales

Brooks Chassaing, Chairman, Chassaing Brothers — Lighting, 7603 Forsythe Blvd., Clayton 5, Mo.

GENERAL COMMITTEES

ADVANCE PLANNING — To study the long range objectives of the Society — its operation, program, publication activities, membership classifications and financial structure, and to make recommendations to Council.

F. C. Winkler, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio.

A. C. Sangster, Vice-Chairman, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

G. W. Beals — A. B. Oday
Edward M. Chellew — Glenn E. Park
W. P. Lowell, Jr. — L. C. Twichell
J. D. Mitchell — J. D. Whitnell
R. M. Zabel

ADVISORY BOARD TO THE PRESIDENT — To examine the organization, accomplishments, and assignments of committees and prepare not later than July 1 of each year a proposed list of committees and personnel; and to evaluate costs and benefits of present and proposed Society services.

G. J. Taylor, Chairman, Day-Brite Lighting Inc., 161 E. 42nd Street, New York 17, N. Y.

J. B. Browder — R. G. Slauer
J. R. Chambers — M. N. Waterman

ALLIED ARTS — To encourage and assist local competitions in allied arts, in cooperation with technical committees and interested local groups.

Karl A. Staley, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

J. D. Whitnell, Vice-Chairman, Arizona Public Service Co., P. O. Box 2591, Phoenix, Ariz.

Carl Albach — M. B. Moore
W. D. Crites — Joseph Morbito
Roy Dahlin — Roy Palmer
Eugene Frost — Kenneth Parsons
A. B. Gallion — J. C. Penafeather
J. H. Jensen — R. C. Putnam
A. R. Keeler — J. A. Russell
T. J. Killian — B. J. Sabaroff
Lucien Kight — Foster K. Sampson
J. O. Kraehenbuehl — G. E. Shoemaker
Onnie Monkki — Rollo G. Williams

Agriculture Colleges

J. P. Ditchman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Lighting Lectures

J. I. Tugman, Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

BOARD OF NOMINATION — To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

Duncan M. Jones, Chairman, Curtis Lighting Co. of Canada, Ltd., 195 Wicksteed Ave., Leaside, Toronto, Ont.

R. F. Hartenstein — M. N. Waterman
and regional representatives

CONSTITUTION AND PROCEDURES — To prepare proposed amendments to the Constitution and By-Laws, to prepare statements of policies and procedures consistent with the Constitution and By-Laws, and to report to Council.

R. F. Hartenstein, Chairman, The Ohio Edison Co., Akron, Ohio.

(*Continued on page* 32A)

(*Continued from page 31A*)

L. E. Barbrow — C. C. Keller
G. W. Beals — Walter Sturrock
G. F. Dean — L. C. Twichell
N. C. Warner

DEFENSE COORDINATING — To contact various Government Agencies concerned with National Security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper Government Channels.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 212 King Street, W., Toronto, Ont.

A. F. Wakefield, Co-Chairman, The Wakefield Co., Vermilion, Ohio.

H. R. Blackwell — O. P. Cleaver
R. B. Brown, Jr. — John S. Walsh

HISTORICAL — To assemble and make available for current reference and to prepare in suitable and durable form for posterity, such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

S. G. Hibben, Chairman, 31 Clinton Ave., Montclair, N. J.

S. B. Williams, Vice-Chairman, Brooks Street, Jamestown, R. I.

J. L. Stair, Secretary, Harbert, Berrien County, Mich.

W. P. Bear — Leo Dolkart
R. B. Burton, Sr. — C. A. B. Halvorson
James Cravath — H. L. Logan
Julius Daniels — G. E. Stickney

LIGHTING SERVICE — To stimulate and promote the discussion and practical application of lighting recommendations and to conduct a Lighting Service Forum in connection with the National Technical Conference.

C. W. McCormick, Chairman, Connecticut Light & Power Co., P. O. Box 2010, Hartford, Conn.

Herb Anderson — Carter Lewis
Robert Babcock — L. E. Tayler
Walter Ball — J. Thomas
A. C. Brodeur, Jr. — Carlton Thompson
Berlon C. Cooper — C. E. Waldron

MEMBERSHIP — To develop plans and supervise the operation of the individual membership activity of the Society.

Brooks Chassaing, Chairman, Chassaing Brothers — Lighting, 7603 Forsythe Blvd., Clayton 5, Mo.

J. C. Forbes, Vice-Chairman, General Electric Co., Nela Park, Cleveland 12, Ohio.

Frank E. Brown, Jr. — Byron F. Lyth, Jr.
G. B. Buck, Jr. — Gerald Marks
Roy E. Dahlin — Glenn E. Park
E. I. Dinsmore — Blair Plowman
Ed Ehret — Joseph Thomas
J. M. Gensburger — Allen S. Turner

Task Subcommittee

Gerald Marks, Chairman, Lighting Associates, 53 W. Jackson Blvd., Chicago, Ill.

Roy E. Dahlin — A. S. Turner

NATIONAL TECHNICAL CONFERENCE — To be completely responsible, subject to the approval of Council, for the general coordination of all conference activities, for selecting and recommending time and place, for review of the plans and budgets of the National Technical Conference Executive Committee, and in cooperation with the Papers Committee for the satisfactory time allocation for the Technical Papers sessions, according to Procedures and Policies as adopted by Council.

C. L. Amick, Chairman, Day-Brite Lighting Inc., 5411 Bulwer Ave., St. Louis 7, Mo.

J. W. Bateman — J. D. Mitchell
J. B. Browder — A. C. Sangster
Brooks Chassaing — J. A. Schneller
H. F. Davidson — J. S. Schuchert
J. C. Forbes — C. C. Shotwell
R. K. Lothrop — Carlton M. Thompson
W. P. Lowell, Jr. — John S. Walsh
C. W. McCormick — J. Carl Wilson

1958 Conference Executive Committee

J. W. Bateman, Chairman, Canadian General Electric Co., Ltd., 212 King St., W., Toronto, Ont.

R. C. Allison — L. R. Nordby
W. A. Dalrymple — Norman Scott
G. E. Davidson — R. A. Sclater
G. F. Dean — I. D. Smith
W. L. Hawley — G. E. Wallace
R. P. Lindsay — Mrs. J. Carl Wilson
E. E. Machtinger — Ed Wilson

Task Subcommittee

A. C. Sangster, Chairman, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

J. B. Browder — C. W. McCormick
H. F. Davidson — J. Dixon Mitchell
R. F. Hartenstein — Virginia Skinner
F. C. Winkler

PUBLIC RELATIONS AND INFORMATION — To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans for the Society.

J. R. Chambers, Chairman, Appleton Electric Co., 1701 Wellington Ave., Chicago 13, Ill.

W. A. Dalrymple, Vice-Chairman, Amalgamated Electric Corp., Ltd., 384 Pape Ave., Toronto, Ont.

Herb Cornell — John Ronayne
E. H. Gallet — C. C. Shotwell
T. W. Lauer — Joe Thomas
L. E. Tayler

REGIONAL ACTIVITIES — To represent the respective Regions before the Council and to keep the Council informed regarding the affairs of the Regions. To stimulate Society activities, to encourage joint meetings of Sections and Chapters including Regional Conferences within the respective Regions, and to promote the expansion of the Society.

J. B. Browder, Chairman, Georgia Power Co., 75 Marietta St. N. W., Atlanta 1, Ga.

James A. Banton — Joseph A. Schneller
A. Eugene Fleming — C. C. Shotwell
Reuben K. Lothrop — R. M. Taylor
George L. Morris — Carlton M. Thompson
Kenneth Reid — C. E. Waldron
J. Carl Wilson

RESIDENCE LIGHTING FORUMS — To stimulate and assist the Residence Lighting Forums of the Society and to encourage the formation of additional Forums. To conduct a Residence Lighting Forum in connection with the National Technical Conference.

Virginia Skinner, Chairman, Long Island Lighting Co., Old Country Road, Mineola, L. I., N. Y.

Clarence Cockrell — T. S. Kelly
William Downey — Rita Kuzell
Benjamin Duhov — Ruth Lieb
Lillian Eddy — Ruth Morris
Eve Freyer — Elizabeth O'Kelley
Lloyd Gabler — Jan Reynolds
Katherine Goodall — O. J. Scodock
Benjamin Goodman — Marion Seitz
Richard Graf — J. Vernon Sharp
Mary Webber

STUDENT MEMBERSHIP — To plan and implement a program to stimulate interest in Society activities and membership among college faculty and students; and to encourage the formation of student branches and assist in their operation and programs.

John O. Kraehenbuehl, Chairman, 10 Scott St., Broadmoor Park, Colorado Springs, Colo.

P. M. Alden — R. C. Paslay
M. E. Broom — Walter Sturrock

SUSTAINING MEMBERSHIP — To develop plans and supervise the operation of the Sustaining Membership activity in the Society according to the Procedures and Policies adopted by Council.

C. C. Keller, Chairman, The Holophane Co. Inc., 342 Madison Ave., New York 17, N. Y.

W. W. Booth — C. C. Shotwell
Fred Guth — E. J. White

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

R. F. Hartenstein, Chairman, The Ohio Edison Co., Akron, Ohio.

J. R. Chambers — W. P. Lowell, Jr.
M. N. Waterman

TASK COMMITTEES

HEADQUARTERS LOCATION — To study all factors affecting choice of future location of Society Headquarters and to submit a recommendation to Council.

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

D. M. Jones — L. E. Tayler
R. C. Paslay — John S. Walsh
J. D. Whitnell

I.E.S. - U. S. PUBLIC HEALTH SERVICE — To outline a method of making a survey of the visual factors of the working environment and the workers' vision and evaluating the findings in terms of visual comfort and effectiveness and eye health.

J. F. Parsons, Chairman, Niagara Mohawk Power Corp., Electric Bldg., Buffalo 3, N. Y.

Mrs. Tula Brocard — Henry N. Doyle
L. J. Cahill — Neal Jacobus
George Clayton — A. L. Koven
R. P. Teele

SIGN LIGHTING — To study the lighting of signs, both exterior and interior and report thereon.

C. N. Laupp, Chairman, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee, Wis.

R. E. Faucett — W. H. Kahler
H. B. Fletcher — R. J. Neu
A. L. Hart — M. F. McCann

TECHNICAL COMMITTEES

AVIATION — To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

L. C. Simpson, Chairman, AGA Division, Elastic Stop Nut Corp. of America, P. O. Box 38, Elizabeth, N. J.

M. A. Warskow, Vice-Chairman, Port of N. Y. Authority, 111 Eighth Ave., New York 11, N. Y.

M. A. Mortensen, Secretary, General Electric Co., Nela Park, Cleveland, Ohio.

J. F. Angier — W. D. Howell
F. C. Ashe — J. P. Hoxie
E. Boghosian — Warren Hulke
F. B. Brady — W. A. Jensen
F. C. Breckenridge — G. M. Kevelin
W. D. Callaghan — W. E. Koneczny
P. B. Clark — A. L. Lewis
G. K. Clement — D. C. Miller
D. I. Coggins — J. K. Newell
H. A. Cramer — H. J. C. Pearson
C. A. Douglas — W. A. Pennow
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(*Continued on page 34A*)

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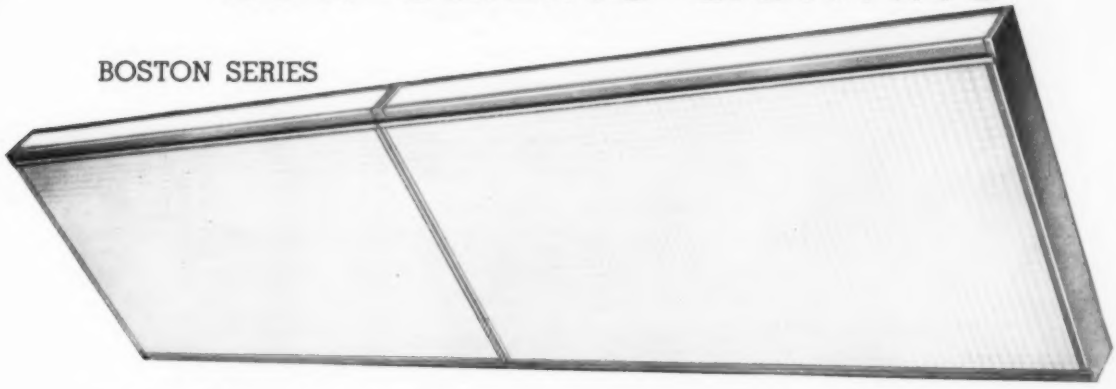

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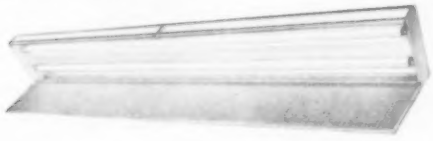

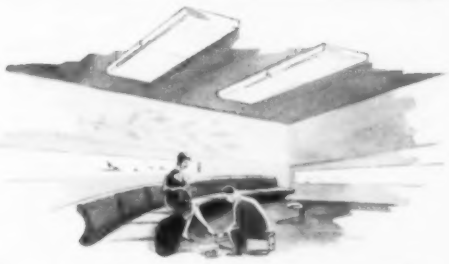

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2-400 watt	4	4	NONE	3
1-700 watt	3	NONE	NONE	3
1-1000 watt (H12)	4	4	NONE	3
1-1000 watt (H15)	3	3	NONE	1
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1-175 watt	4	NONE	NONE	NONE
1-250 watt	4	NONE	2	NONE
2-250 watt	NONE	NONE	2	NONE
1-400 watt	4	NONE	5	NONE
2-400 watt	4	NONE	6	NONE
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(*Continued on page 40A*)

(Continued from page 39A)

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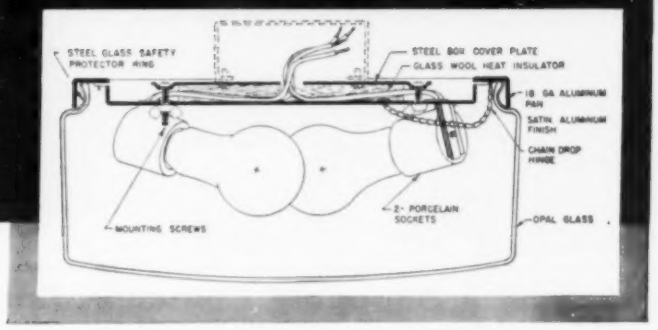

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For lighting engineers, lighting planners, and architects interested in outdoor lighting problems and trends.

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The Answer: Revere incandescent floodlighting, highlighting true color of cars. Two No. 4213-P floodlights are mounted 24 feet above grade with 31 feet spacing except for driveways. Thirteen 5-light cluster assemblies No. 3245 are mounted 9 feet above grade to add "sparkle" to cars on display. Floodlights use 1000-watt PS-52 clear lamps. Cluster lights use Par 38 150-watt lamps. For easy maintenance, 13 Revere 199-E-24 hinged poles support floodlights.

No. 4213-P Floodlights

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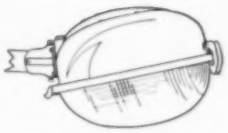
The Problem: I.E.S. recommended *minimum* average footcandles not considered adequate for one of Chicago's heaviest travelled streets because of its high accident rate and low reflectance of newly paved blacktop surface. Design for uniform 3 footcandles average maintained illumination.

The Answer: Revere No. 2284 Endoval Type III street lighting luminaires with 400-watt E-H1 mercury lamps. Endovals with 10° tilt are mounted 29 feet above grade with 83 feet opposite spacing. Overhead wiring is used to take advantage of existing power after recent removal of street car line.

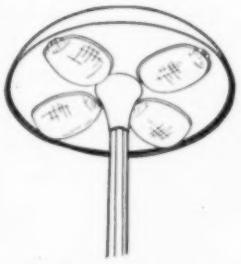


No. 2284 Type III Endoval

Lighting a Shopping Center Parking Lot

The Problem: To provide an attractively illuminated parking lot appealing to shoppers, and to enable those using the area to locate their automobiles easily and safely. Parking area is 240 feet by 106 feet.

The Answer: Three Revere No. 5440 Ultra-Lites mounted 34 feet above grade, and spaced on 70 foot centers, to provide an average illumination of 4 foot candles. Each Ultra-Lite uses four E-H1 400-watt mercury lamps positioned for widest coverage and highest illumination level. Ultra-Lites throw square light patterns which overlap to eliminate "dark spots" and build up light values in fringe areas.



No. 5440 Revere Ultra-Lite

No matter what the lighting problem — if it's outdoors, Revere has the equipment, or can engineer it, to provide your best lighting answer. Write for catalog covering Revere's complete line of matched outdoor lighting equipment.

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(Continued from page 42A)

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Chairman — J. P. GAILLOUX, Northern Electric Co., 2620 Notre Dame St., Trois Rivieres, Que.

(Continued on page 46A)

Committee Personnel

(*Continued from page* 40A)

Dimensional and Operational Standardization of Electrical Lamps and Auxiliaries for Gaseous Discharge Lamps, C78
Thomas S. Kelly

Inspection Requirements for Motor Vehicles, D7.1
R. P. Teele

Standard for Motion Pictures, PH22
Sectional Committee PH2
Photographic Sensitometry
To be appointed

Office Standards, X2
Subcommittee 1, Office Equipment (furniture)
Subcommittee 2, Office Papers
Subcommittee 5, Business Machines
Roger Waite

Letter Symbols and Abbreviations for Science and Engineering, Y10
Priscilla Presbrey

Drawing and Drafting Room Practice, Y14
Priscilla Presbrey

Graphic Symbols and Abbreviations for Use on Drawings, Y32
Priscilla Presbrey

Standardization in the Field of Photography, Z38
To be appointed

Safety Color Code, Z53
W. H. Kahler

Colors for Industrial Apparatus Equipment, Z55
W. H. Kahler

Standardization of Optics, Z58
Priscilla Presbrey

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INDUSTRY COMMITTEE IN CONNECTION WITH REVISION OF HANDBOOK OF INTERIOR WIRING DESIGN
A. C. Bredahl
G. E. Shoemaker

INSTITUTE OF TRAFFIC ENGINEERS
Joint Committee on Highway Lighting
To be appointed

INTER-SOCIETY COLOR COUNCIL
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NATIONAL COMMITTEE ON UNIFORM TRAFFIC LAWS AND ORDINANCES
R. P. Teele

Vehicle Lighting
R. P. Teele
V. J. Roper, Alternate

(*Continued on page* 54A)

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(*Continued from page* 45A)

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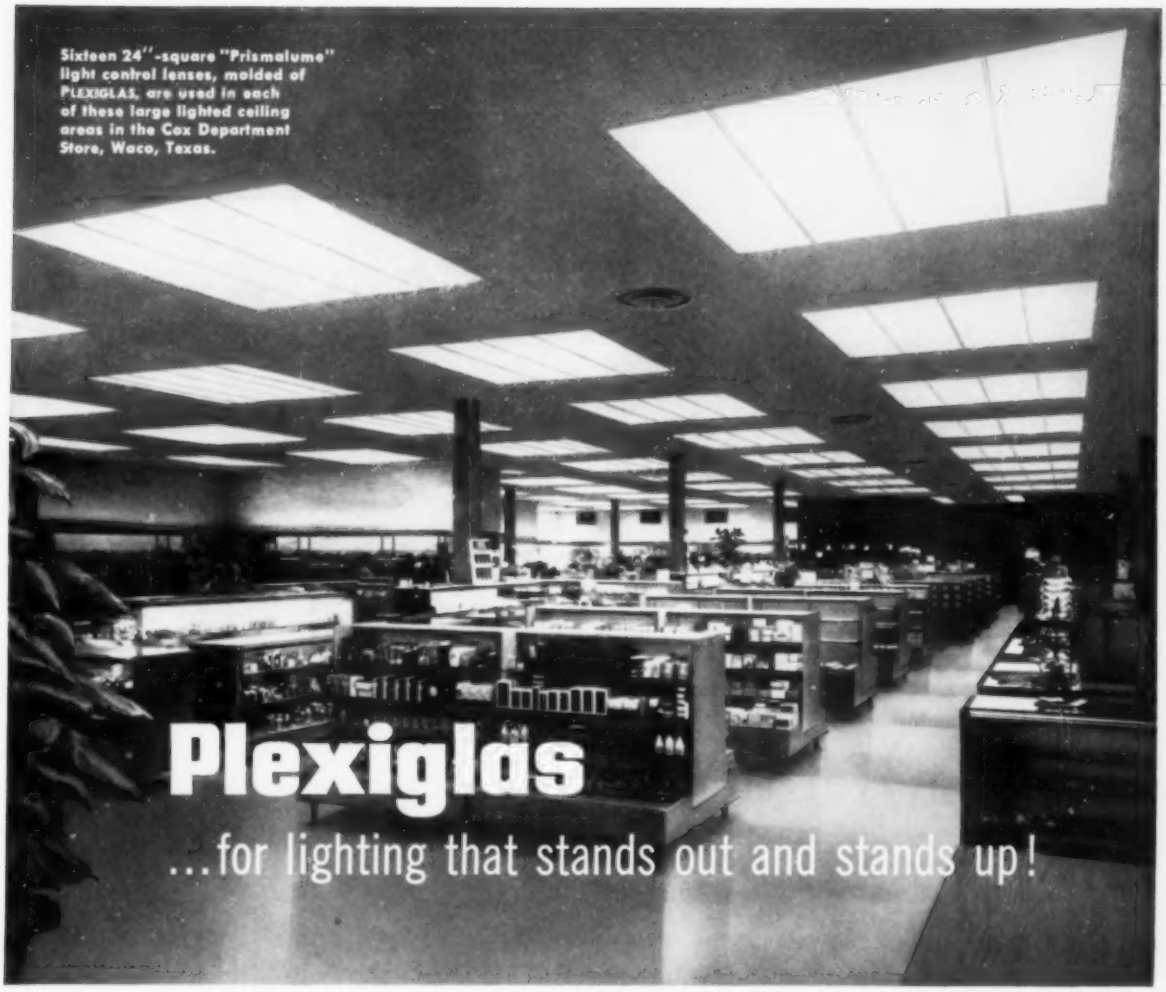
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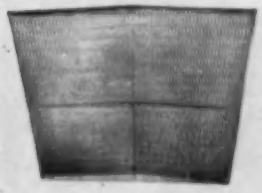

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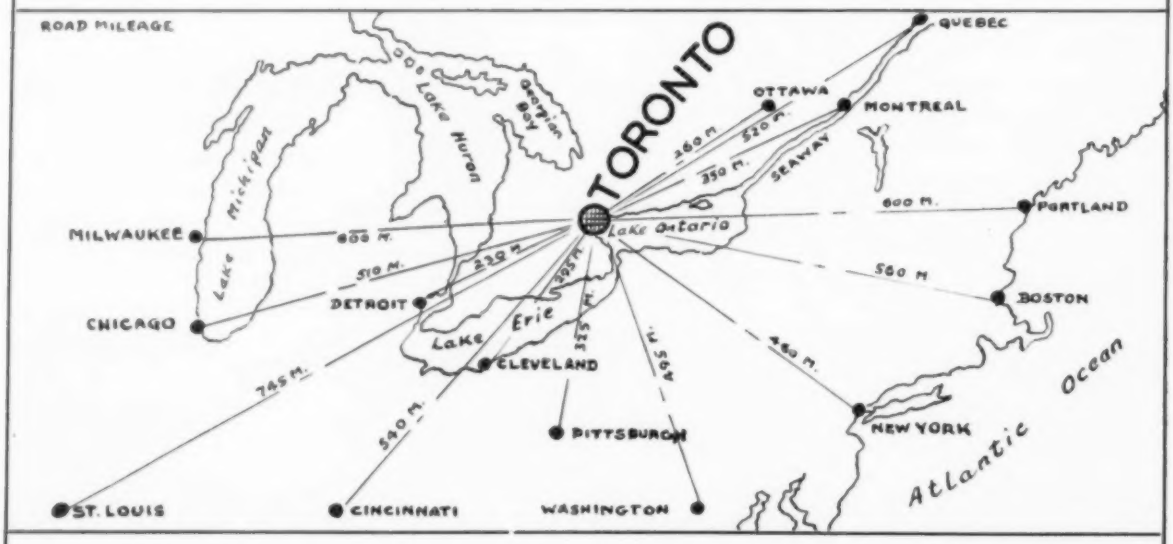

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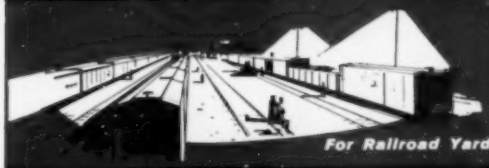
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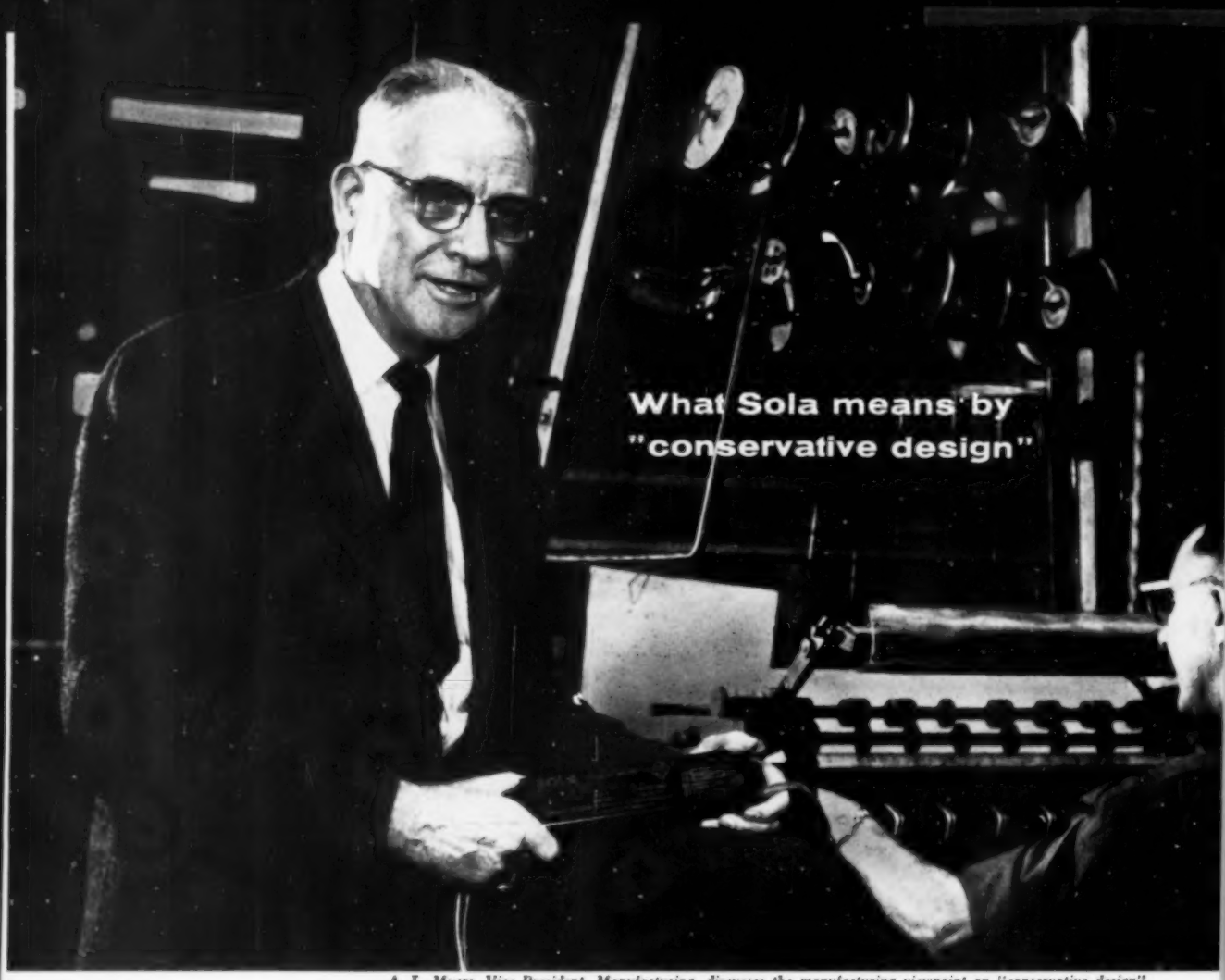

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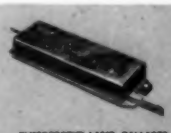
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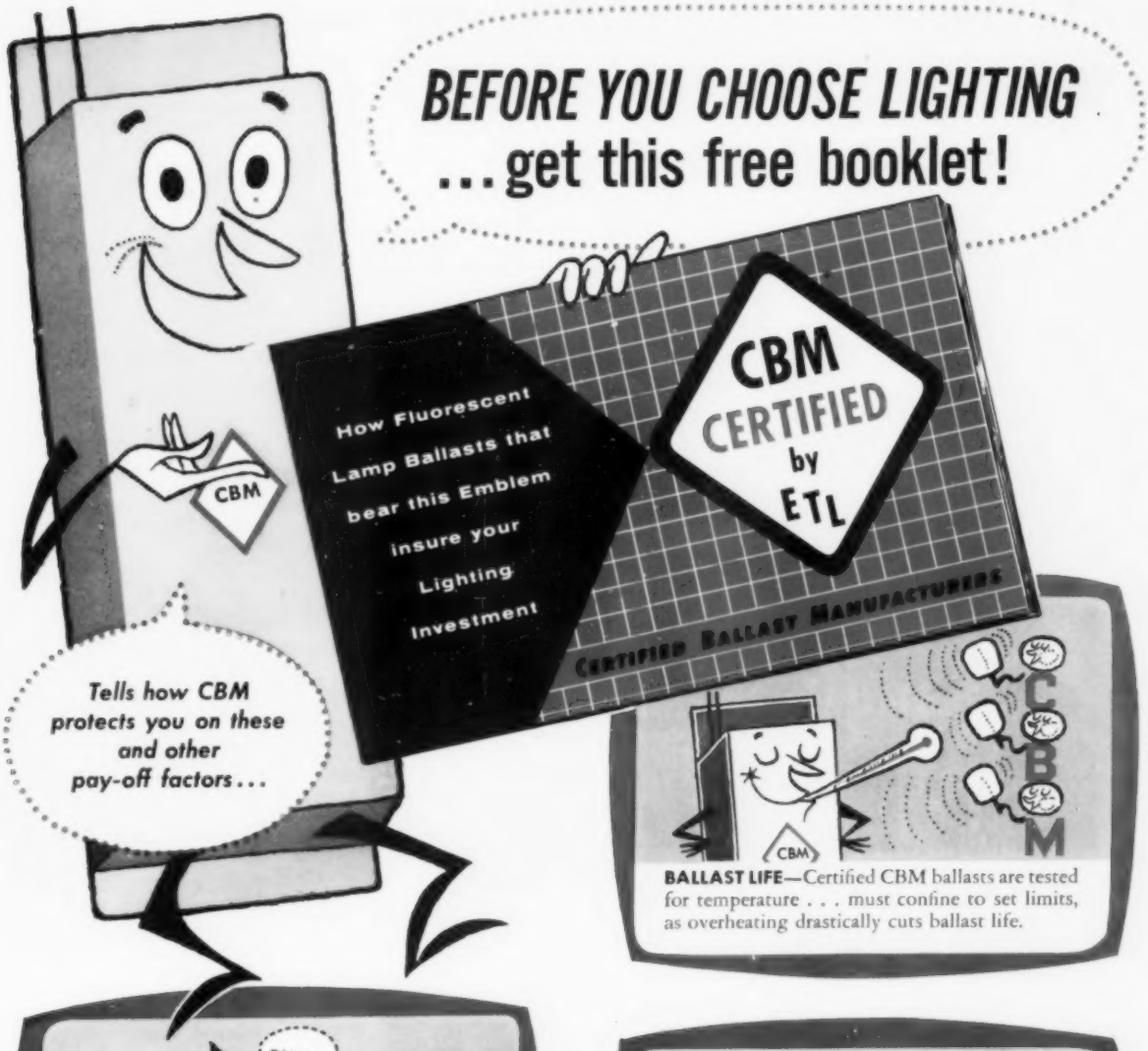
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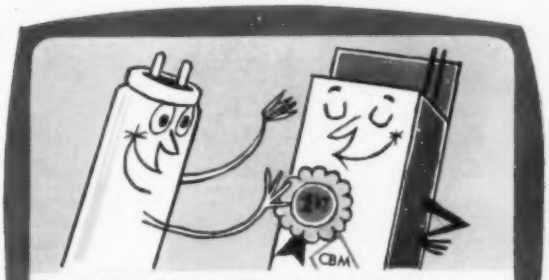
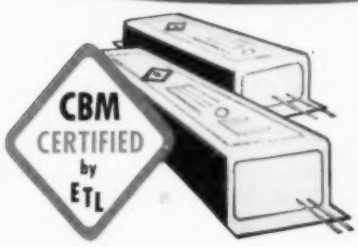


RATED LIGHT OUTPUT—Certified CBM ballasts are "tailored to the tube" . . . assure rated light output, steady light, peak lighting performance.



Send for this free booklet and learn how these factors and 11 others help insure your lighting investment when you buy fixtures equipped with Certified CBM ballasts.

Eight leading manufacturers now make up the association of

CERTIFIED BALLAST MANUFACTURERS

2116 KEITH BUILDING • CLEVELAND 15, OHIO

Participation in CBM is open to any manufacturer who wishes to qualify

CBM-6-U

NO. 6163 — 24" Diameter (left)
Wired for four 100W lamps plus a 500W R-40 floodlamp for concentrated downlighting thru the louver bottom.

NO. 6181 — 12" Diam. Cylinder (right)
Wired for three 100W lamps plus a 500W R-40 floodlamp for concentrated downlighting thru the louver bottom.

New distinctively styled designs provide high intensity glare-free illumination, while adding charm and beauty to church or public building. Special design service available. Write for new illustrated catalogs.

the creative beauty of

NL

LIGHTING

NO. 6152 — 24" Top Gallery
Wired for seven 100W lamps plus a 500W R-40 floodlamp for concentrated downlighting thru the louver bottom.

NO. 1833 — Featured in two sizes for 6" and 8" diameter half-cylinders.

Fine exterior lighting of oil copper and bronze material . . . designed in standard bronze or satin pewter finish to match aluminum or stainless steel building trim.

NO. 1791 — Available in 6½", 8" and 10" square body diameter sizes.

Lighting by Novelty features the creative skill of more than fifty years experience in architectural design, metal craftsmanship and engineered lighting.

NL Corporation formerly The Novelty Lighting Corporation

2490 EAST 22nd STREET — CLEVELAND 15, OHIO

Designers and Manufacturers . . . Since 1905

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(*Continued from page* 46A)

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National Academy of Sciences
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(*Continued from page* 28A)

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Hawkins, K. R., Alkco Mfg. Co., Chicago, Ill.

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Mattox, W. E., Smithcraft Lighting Division, Chicago, Ill.

Sereda, A. E., Jr., Schmidt, Garden & Erickson, Chicago, Ill.

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Stevens, A. C., Jr., Alkco Mfg. Co., Chicago, Ill.

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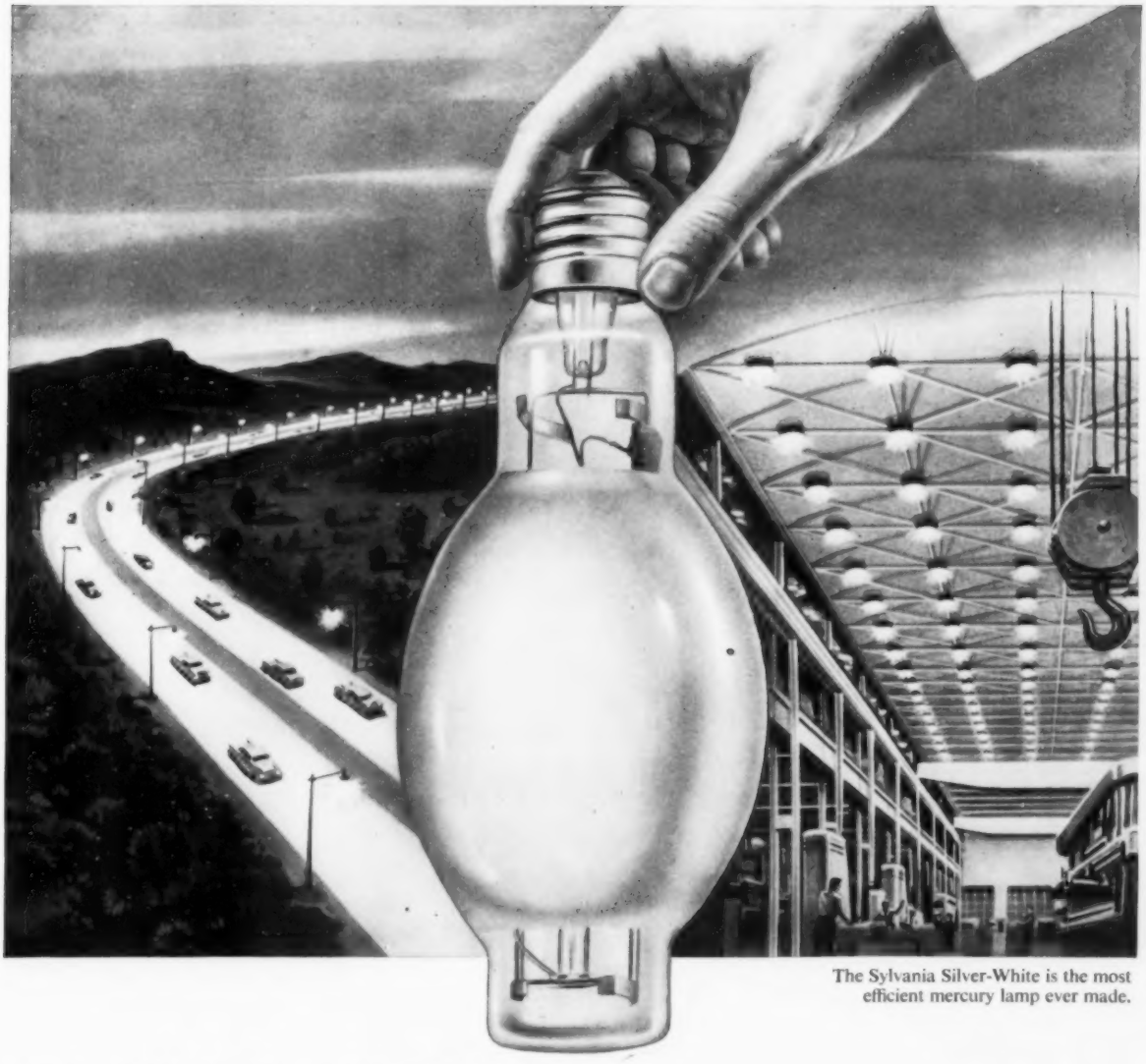
(*Continued on page* 56A)



The Sylvania Silver-White is the most efficient mercury lamp ever made.

For highway . . . or high-bay

. . . the one-lamp answer to both lighting needs

Today's most efficient mercury-vapor lamp is the new Sylvania Silver-White.

The greater light output and superior color quality of the Silver-White makes it an effective, versatile lighting source . . . it serves the high requirements for such widely different applications as highway lighting and high-bay plant illumination with unequalled efficiency.

Sylvania's Silver-White actually delivers up to 33% more lumens of light than previous color-improved mercury-vapor lamps. The 100-watt lamps, for example, are producing an unprecedented 4000 lumens in actual installations.

Sylvania Silver-White lamps cost no more than conventional color-improved lamps—but offer the combined economies of superior light output and superior construction.

Silver-White lamps are available in 100-, 175-, 400-, 700-, and 1000-watt types to meet the needs of industry for efficient high-bay indoor lighting and outdoor illumination for parking and loading areas . . . and for the governmental requirements for effective highway lighting.

For complete information about the Sylvania Silver-White Mercury Vapor lamp, call your local representative, or write:

SYLVANIA ELECTRIC PRODUCTS INC.
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60 Boston St., Salem, Mass.
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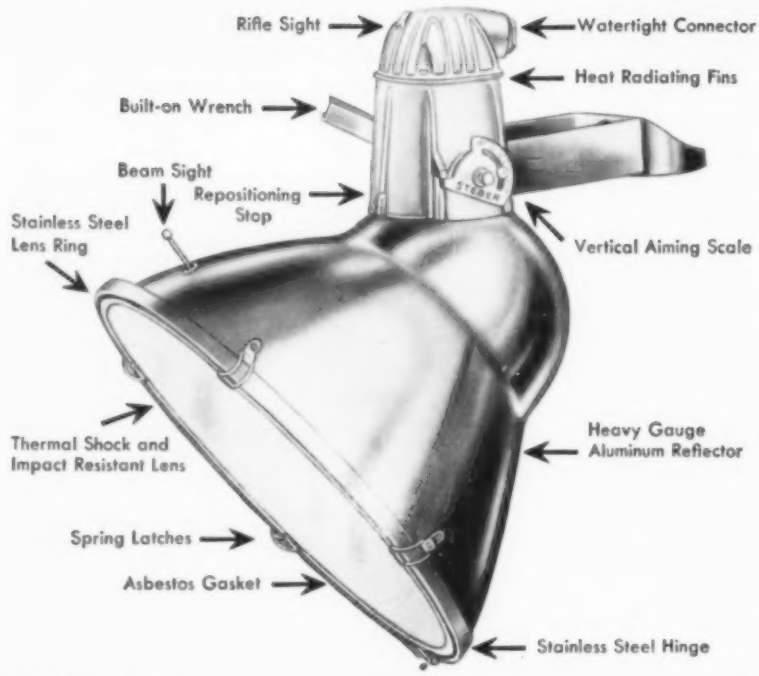
Shell Tower Building, Montreal

SYLVANIA

. . . the fastest growing name in sight

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY



NEW "SERIES 4000" SPORTS AND INDUSTRIAL FLOODLIGHTS HAVE ALL THE FEATURES YOU WANT!

You can pay more, but you can't buy better floodlights!

Steber floodlights meet any and all job requirements! They provide efficient, economical high intensity illumination for sports areas of all kinds, parking lots, protective and working light for industrial plants, railroad yards and construction jobs.

Steber floodlights are easier to install, easier to wire, easier to aim. Exclusive ANODAL processing gives the heavy gauge aluminum reflector a smooth, glass-hard, ageless finish inside and out. You get higher efficiency, easier maintenance, better looking installations.

Steber "Series 4000" Floodlights meet NEMA Specifications FL 6-210 for general purpose enclosed floodlights 300 to 1500 watts and 400 watt mercury vapor lamps.

Write for new Steber "Series 4000" literature today.

Lighting Units **STEBER** *for Every Need*

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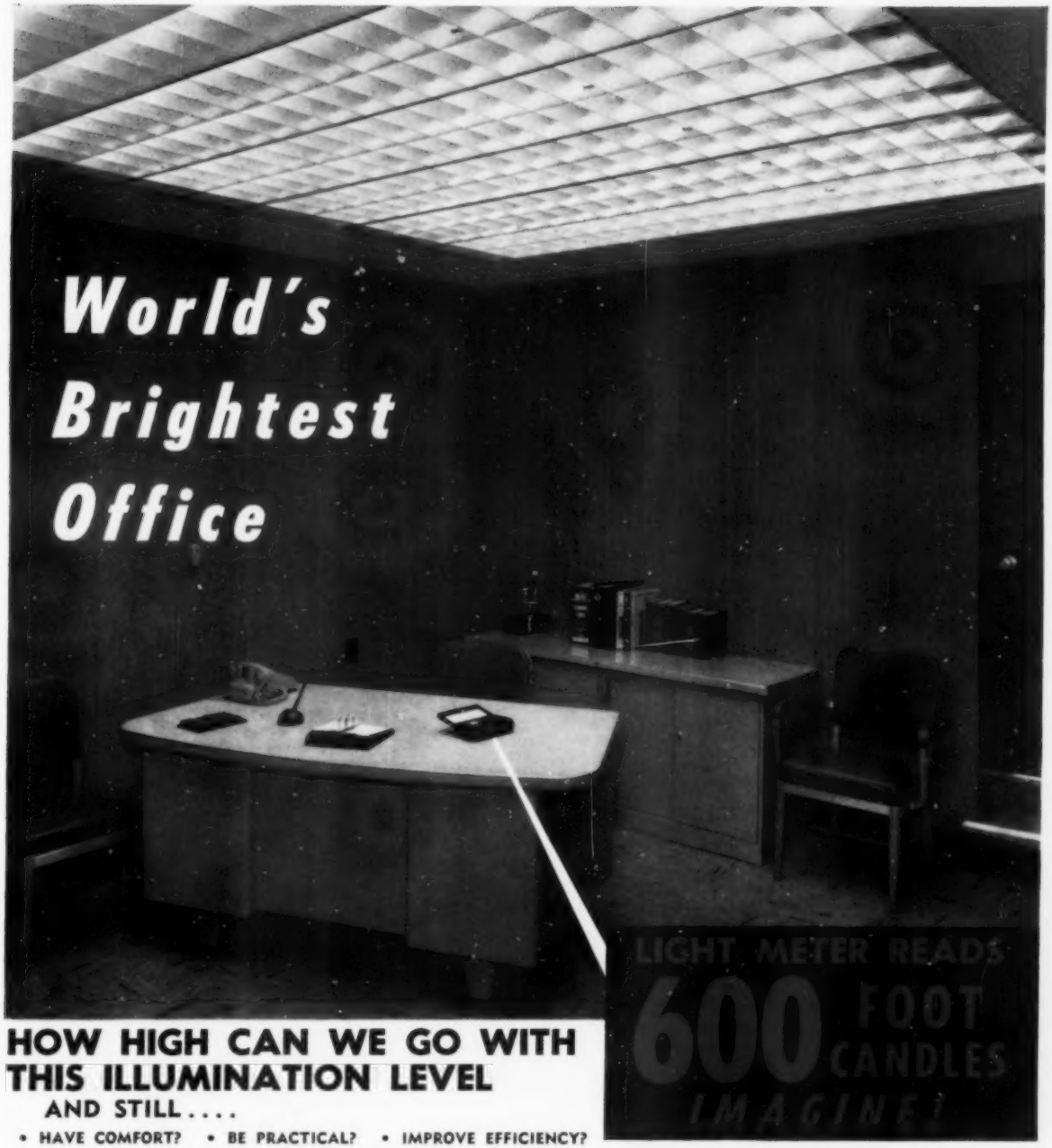
(Continued on page 58A)



HOW HIGH CAN WE GO WITH THIS ILLUMINATION LEVEL

AND STILL....

• **HAVE COMFORT?** • **BE PRACTICAL?** • **IMPROVE EFFICIENCY?**

In an effort to learn some of these answers this office was lighted to produce an initial 640 ft. candles with the new Power Groove lamps and Controlled Brightness Paramount Fixtures.

Everyday recommended foot candle levels are going up - up, and ultimately we approach the **"Sight Barrier"**—that point at which the level of illumination necessitates so much glare that it becomes uncomfortable and destroys the advantages incurred through better lighting.

This barrier was no doubt reached at the 50 to 100 ft. candle levels with incandescent lighting. It was then penetrated with the advent of Fluorescent lighting and a new one confronted at perhaps the 200 to 250 ft. candle level. Now this sight barrier has been crossed by lighting comfortably this office with over 600 ft. candles.

THE ANSWERS FOUND? — AS YET THERE IS NO KNOWN LIMIT ON HOW HIGH WE CAN GO! It is simply established that the Sight Barrier or comfortable lighting level will be determined by the **fixtures** which produce the illumination. Light reflecting surfaces, contrasts, colors, etc., have become such well-known and practised facts that the only avenue left, to reach high levels of illumination with comfort, is **through the lighting fixture.**

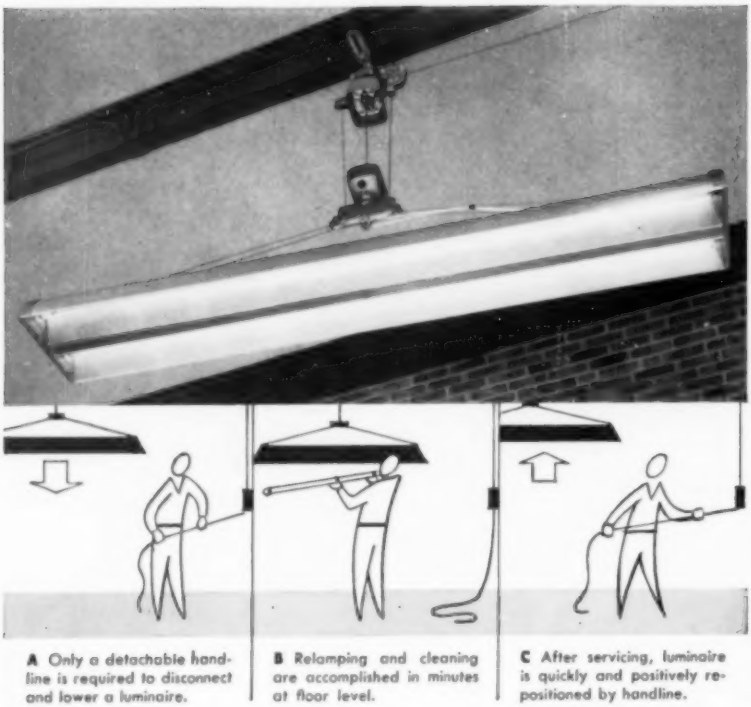
Shielding, low brightness aluminum, scientifically curved reflecting surfaces, all add up to **"Controlled Brightness."** Investigate what these fixtures can do for you to produce heretofore unheard-of levels of illumination — **with comfort!**

U. L. Approved and Tested with Power Groove, VHO and HO Lamps

Paramount INDUSTRIES, INC.
G-1080 N. BALLENGER HWY., FLINT, MICH.

PARAMOUNT INDUSTRIES
CROSSING THE SIGHT BARRIER WITH CONTROLLED BRIGHTNESS

NOW!... ONE MAN CAN MAINTAIN HEAVY LUMINAIRES AT FLOOR LEVEL WITH THOMPSON TRIPLEX HANGERS



A Only a detachable handline is required to disconnect and lower a luminaire.

B Relamping and cleaning are accomplished in minutes at floor level.

C After servicing, luminaire is quickly and positively repositioned by handline.

Designed to handle hi-bay luminaires weighing up to 120 pounds, the new Thompson **TRIPLEX** Hanger is the most practical means of servicing heavy fixtures quickly, safely, economically. It is recommended for use with new fluorescent luminaires featuring ultra-high output lamps and clusters of mercury and incandescent fixtures.

TRIPLEX Hangers permit one unskilled man to relamp and clean a luminaire without climbing or electrical hazards . . . extra manpower . . . space-consuming scaffolds . . . costly auxiliary equipment.

Featuring a new multiple-fall pulley system with a 3-to-1 mechanical advantage, the **TRIPLEX** Hanger is fabricated from durable corrosion-resistant components to assure years of dependable service and trouble-free performance.

For specification details, write today for Bulletin TR-57.

T-E

THE THOMPSON ELECTRIC CO.

P. O. Box 873-K • Cleveland 22, Ohio

5961-TE

(*Continued from page 56A*)

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(*Continued on page 60A*)

Another Lighting Installation that Speaks for Itself and says Volumes – by Litecontrol

Only a few short years ago, no amount of money could buy quality lighting such as you see above.

The photo shows a very practical way of illuminating a large banking area graciously and *inexpensively* — with LITECONTROL standard fixtures.

We believe the excellence of the pattern arrangement speaks for itself — both in its eye appealing qualities and in the provision for more light in the work areas than in the public area. The Holophane acrylic lenses are almost two feet square and extremely efficient and *low in brightness.*

Cleaning and servicing the fixtures is very easy. Fingertip pressure on triggers opens fixture doors easily. Doors are closed just as easily by simply pushing them back in place.

Remember . . . even with lighting budgets tighter, you can get lighting that's better — with LITECONTROL.

INSTALLATION:
Hartford National Bank & Trust Company
Middletown Branch, Middletown, Conn.
ARCHITECT:
Jeter & Cook, Hartford, Conn.
ENGINEER:
Walter Heywood of Henri VanZelm Associates
West Hartford, Conn.
ELECTRICAL CONTRACTOR:
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FIXTURES:
Litecontrol No. 8344 4 lamp recessed 2' x 4'
fixtures, using Holophane #6025 acrylic
PRISMALUME* lenses and 40 watt Standard Cool
White Rapid Start Lamps
CEILING HEIGHT:
18' — 0"
INTENSITY:
Average on desk tops in work areas,
100 foot-candles in service
*Reg. Holophane Co., Inc.

LITECONTROL

Fixtures

KEEP UPKEEP DOWN

LITECONTROL CORPORATION,

36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Don't let lighting repairs torture your customer's budget

When Squint the Light Pirate sabotages a fluorescent fixture and the tube blinks out, most maintenance men scurry for a new tube. That one won't light either—and still the trouble isn't spotted. Already your customer has paid for plenty of wasted time.

Here's a way to keep Squint beyond the three-mile limit. Next time you make your lighting recommendations, suggest that your customer call in a local *NALMCO lighting maintenance contractor.*

These experts set up dates at regular intervals to check the guts of your customer's entire lighting system. They operate when they will least interfere with production or office schedules. And because they know more than even Squint does about ballasts, sockets, starters and wiring, they keep trouble bottled up tight.

Your customer deserves all the light you give him—all the light he's paying for. Show him our *free booklet* on cost-cutting lighting maintenance. Write to: NALMCO, P.O. Box 1203, Cedar Rapids, Iowa.

NATIONAL ASSOCIATION OF LIGHTING MAINTENANCE CONTRACTORS

NALMCO

(Continued from page 58A)

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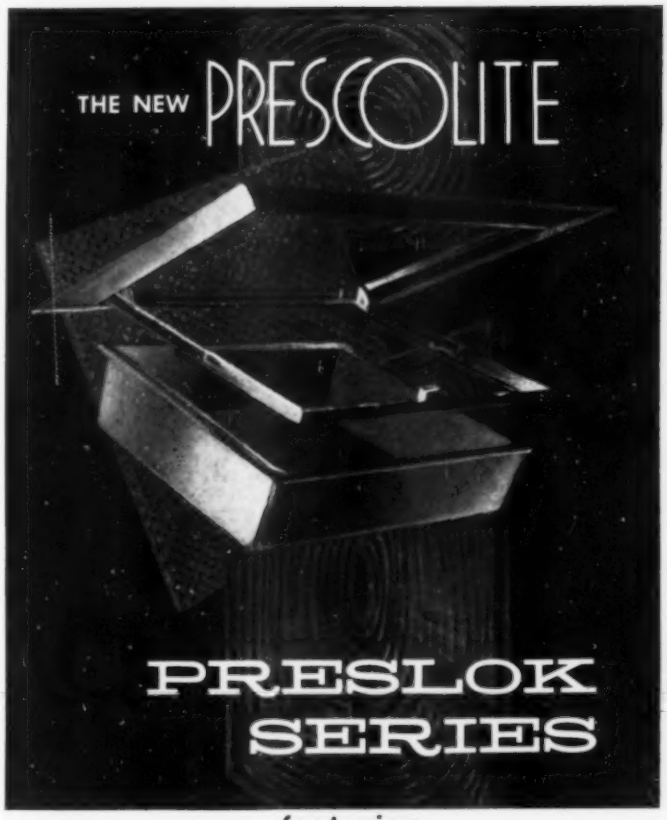
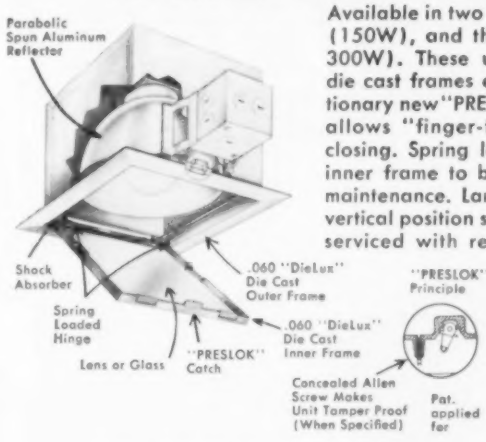
(*Continued on page* 62A)



featuring

A New Conception in Hinged Frames for Recessed Lighting Fixtures


Parabolic Spun Aluminum Reflector
Shock Absorber
Spring Loaded Hinge
Lens or Glass
"PRESLOK" Catch
.060 "DieLux" Die Cast Outer Frame
.060 "DieLux" Die Cast Inner Frame
"PRESLOK" Principle
Concealed Allen Screw Makes Unit Tamper Proof (When Specified)
Pat. applied for

Available in two sizes—the 1014 Series (150W), and the 1317 Series (200-300W). These units utilize "DieLux" die cast frames employing the revolutionary new "PRESLOK" principle which allows "finger-touch" opening and closing. Spring loaded hinge enables inner frame to be easily removed for maintenance. Lamp and socket are in vertical position so that the unit may be serviced with relamping pole. Units employ critically engineered full reflector for maximum performance.

With a touch of the finger or lamp pole changer the inner frame with lens swings down for cleaning or relamping, yet locks firmly in closed position. Special shock absorber prevents glass breakage.
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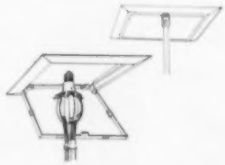

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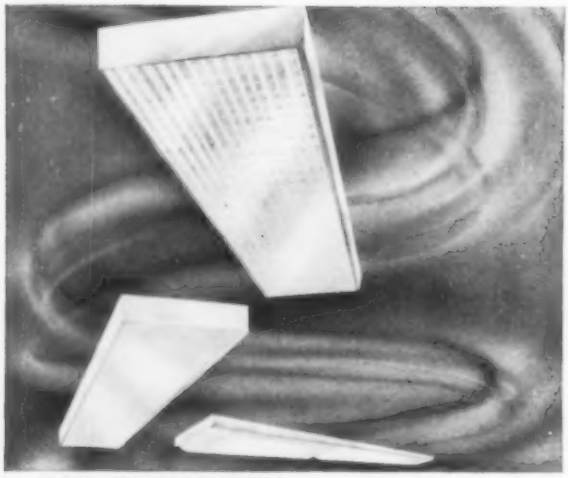

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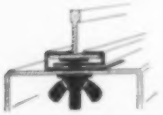

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INDEX TO ADVERTISERS
April 1958

Abolite Lighting Division Jones Metal Products Co.	66A
Advance Transformer Co.	1A
Appleton Electric Co.	49A
Bakelite Co., Div. of Union Carbide Corp.	41A
Brascolite Incandescent Div. Edwin F. Guth Co.	18A
Century Lighting Inc.	65A
Certified Ballast Manufacturers	53A
Corning Glass Works	17A, 50A
Crouse-Hinds Co.	4A
Curtis Lighting Inc.	5A
Eastern Fixture Co.	35A
Fluorescent Fixtures of California	27A
Garden City Plating & Mfg. Co.	6A
General Electric Co., Lamp	29A
Edwin F. Guth Co.	Back Cover
Jefferson Electric Co.	38A
Kirlin Co.	21A
Kopp Glass Inc.	30A
Litecontrol Corp.	59A
R. A. Manning Co.	64A
McPhilben Lighting Co.	24A
Metalcraft Products Co. Inc.	62A
National Association of Lighting Maintenance Contractors	60A
NL Corporation	54A
Paramount Industries Inc.	57A
Perfeclite Company	43A
Photo Research Corp.	63A
Prescolite Manufacturing Corp.	61A
Rambusch Decorating Co.	33A
Revere Electric Mfg. Co.	44A
RLM Standards Institute	Inside Back Cover
Rohm & Haas Co.	47A
Sola Electric Co.	23A, 52A
Starring & Company Inc.	2A
Steber Manufacturing Co.	56A
Sunbeam Lighting Co.	37A
Sylvania Electric Products Inc.	14A-15A, 55A
Thompson Electric Co.	58A
Wakefield Company	Inside Front Cover
R. & W. Wiley Inc.	64A
J. A. Wilson Lighting & Display	51A
Daniel Woodhead Co.	64A

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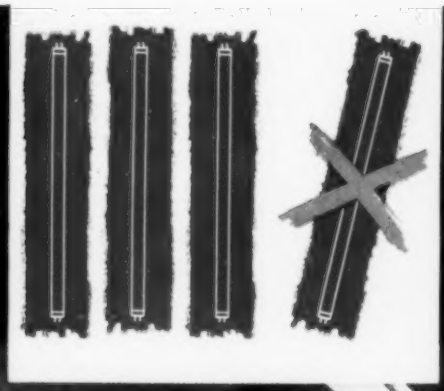

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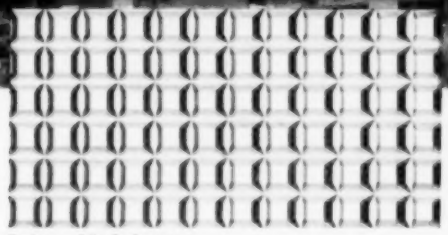

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